SPGR SUB-PROJECT COMPLETION REPORT

Project ID No.: 150

Development and validation of USG Applicator and rice transplanter

Project Duration: From 01 July 2010 to 31 December 2013

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ABBREVIATION

AAO : Additional Agricultural Officer
AEO : Agriculture Extension Officer
ATS : Active Tillering Stage
BARC : Bangladesh Agricultural Research Council
BAU : Bangladesh Agricultural University
BCR : Benefit-cost ratio
BARI : Bangladesh Agricultural Institute
BINA, : Bangladesh Institute of Nuclear Agriculture
BRRI, : Bangladesh Rice Research Institute
DAE : Departmental of Agricultural Extension
DAP : Di-ammonium Phosphate
FMP : Farm Power and Machinery
FMPHT : Farm Machinery and Postharvest Technology Division
FAPAD : Foreign Aided Project Audit Directorate
HYV : High Yielding Variety
HQ : Head Quarter
MoA : Ministry of Agriculture
MTS : Maximum Tillering Stage
MoP : Muriate of potash
NATP : National Agricultural Technology Project
NRM : Natural Resource Management
PIU : Project Implementation Unit
PVC : Polyvinyl Chloride
RCBD : Randomized Complete Block Design
R/S : Regional Station
TSP : Triple super phosphate
UAO : Upazila Agriculture Officer
UMG : Urea Mega Granule
USG : Urea Super Granule
USGA : Urea Super Granule Applicator
ZnSo4 : zinc sulphate

Executive Summary

USG Applicator: A manually operated USG applicator was designed and fabricated for two rows operation in the rice field at spacing of 20 cm x 20 cm. Depth of placement was 6-8 cm. It was modified as adjustable for line to line and plant to plant spacing of 18 x 20 cm, 20 x 20 cm and 22 x 20 cm. In the modified version, covering device was attached to the close vicinity of the dispensing path from 35 to 16 cm to overcome the problems of granules displacement due to water flow entering into the furrows. The drive wheel, skid, output channel, hopper and metering plate in the modified version were made of plastic. Therefore, the total weight of the modified applicator is reduced from 10 kg to 7.5 kg. The field capacity and dispensing efficiency of the modified applicator were found 32.5 decimal/hr and 99% respectively. The depth of USG placement was 6.6 cm in the field. In 18, 20 and 22cm adjustment of the applicator, 187, 168 and 153 kg urea fertilizer per hectare was dispensed for 2.7 gm size granules in the field respectively whereas 168 kg is recommended. It was found in the study that USG applicator can save 7 man-day/ha compare to manual placing of USG. Another model of USG Applicator was designed and prototype was fabricated for mechanical transplanting field which is suitable for 30 cm line to line and 20 cm plant to plant spacing. A total of 19 research station based trials and 51 farmers' field trials were conducted during Aman/10 (06), Boro/11 (13), Boro/12 (11), Aman/12 (11), Boro/13 (12), Aus/13 (2) and Aman/13 (15) seasons. During research station based trials in Aman/10, Average 35 decimal/hr field capacity was found whereas manual USG application capacity was 4.5 decimal/hr. Although yield and yield contributing characters was almost similar in all the treatments but USG gave around 0.5 t/ha yield advantages than prilled urea. However, there have no significant yields different between USG application by machine and hand. In three Aman seasons, a total of 32 trials were conducted including Aman/2013 throughout the project period. During field trials, average walking speed of the operator and field capacity was found to be 2.72 km/hr and 32.5 decimal/hr respectively. Average yield advantages were found to be in Aman season 0.35 t/ha for USG application by machine than prilled urea. In three Boro seasons, a total of 36 trials were conducted throughout the project period. During field trials, average walking speed and filed capacity was found to be 2.46 km/hr and 35.01decimal/hr respectively. Average yield advantages of USG application by machine was found to be 0.511 t/ha from 36 trials in three different Boro seasons compared to prilled urea application. Under large scale validation trials, a total of 320 trials were conducted with the help of DAE.

Rice transplanter: Two walking type and two riding type rice transplanter were collected and evaluated in different soil condition to identify the problems and develop troubleshooting mechanisam during field operation. In research station based trials, the field capacity of walking and riding type transplanter was found to be 37.5 and 90 decimal/hr. The percent of total missing hills were 17.5 and 15%. A total of 08 research station based trials and 66 farmers field based trials were conducted during the project period whereas 01, 11, 13, 01, 11, 21, 02 and 14 trials were conducted during Aus/11, Aman/11, Boro/12, Aus/12 , Aman/12, Boro/13, Aus/13 and Aman/13 season respectively. It was observed from 74 trials that mechanical transplanting gave more yield advantages compare to manual transplanting resulted of higher productive tiller as well as higher grains/m^2. Average yield advantages in Aman and Boro seasons were 0.12 and 0.35 t/ha respectively. Average field capacity and transplanting speed of the walking type transplanter were found to be 39.42 decimal/hr and 0.67 m/s respectively. Total percentages of missing hills considering missing, floating, buried and damage hills were 15.43% whereas 10.5, 19.0 and 16.8% were found in Aus, Aman and Boro seasons respectively. A total of 35 large scale validation trials of rice transplanter were conducted during the project period. Field trials of rice transplanter also conducted to evaluate the field performance in both puddled and un-puddled conditions during Aman/2012 season. Yield and yield contributing characters have no significant different in puddled and un-puddled field. BCR of rice production under puddled and un-puddled conditions gave 1.49 and 1.56 respectively.

An experiment on seedling raising technique was conducted during Boro 2010 and Boro 2012 seasons in BRRI, Gazipur. A total of fourteen treatments combing with different seed covering materials and dry and sprouted seed were used. The highest seedling strength was found for Frame+ dry seed+ soil (227.22) treatment followed by Dry seed+ (Soil+ cow dung) + Sawdust treatment. In Boro 2012 season, the highest no. of seedling per square centimeter was found for Sprouted+ Soil + Soil (4.25) treatment followed by Frame+ Sprouted+ Soil. Treatment T_9 (Sprouted+ Soil + Soil) seedling is more suitable for machine transplanting. A total of 11 hands on training and 01 research workshop were conducted with different categories of farmers, manufacturer and traders. Information regarding developed technology was disseminated to the different stakeholders and recommendations were drawn for future research.

1. **Sub-Project title** : **Development and validation of USG Applicator and rice transplanter**

2. **Principal Investigator/Co-principal investigator**
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4. **Duration of the sub-project:** From: 1 July 2010 to 31 December, 2013

5. **Date of approval** (by the Executive Council/signing of LoA) : 24 June 2010

6. **Total approved Budget (Taka)** : Tk. 1,14,67,830.00
   Total fund received (Tk) : Tk. 1,12,53,718.00
   Total fund Spent (Tk) (Up to Nov. /13) : Tk. 1,11,46,519.00
   Unspent/balance fund (Tk.) : Tk. 1,07,199.00
   Reason for the balance : Salary & terminal benefit of the staff, Honorarium, operating cost, workshop materials, crop cut and final report preparation purposes will be spent in the next month.

7. Justification of undertaking the sub-project

a. Justification for USG Applicator

Urea is one of the major essential elements of plant. The plant takes nutrient available in the root-zone as food for growth and increase yield. The aim of applying fertilizer to the root-zone is for the efficient use by the plant. Farmers of Bangladesh, use prilled urea as a source of nitrogen of which major portion is imported at the expense of hard earning foreign currency. In conventional practice, the field efficiency of prilled urea is very low. The efficiency of granular urea is more than prilled urea. On the basis of size and weight, there are three kinds of granular urea e.g. 90 gm. 1.8 gm and 2.7 gr. The 90 milligram weight granule is known as urea super granule (USG). Three USG are used in one place for Boro rice and 2 nos. for Aus and Aman rice. Another two types of granules (1.8 gm and 2.7 gm) are known as urea mega granule (UMG). For Aus and Aman rice cultivation, one UMG of 1.8 gm and 2.7 gm are used in one place respectively. Deep placement of urea super granules in transplanted rice is an agronomically efficient and environmentally safe as compared with the traditional application method of prilled urea.

The proper deep placement of USG decreases urea-N losses, improves N availability to rice plants and eventually helps to increase grain yields significantly, especially at N rates that small rice farmers can afford. However, the deep placement of USG by hand is a slow hazardous field operation and requires too much labor. About 6-8 workday/ha is required for manual placement of USG in rice transplanted field. Due to labor intensiveness and drudgery of placing, USG adoption by rice farmers has become a limiting factor. So a mechanical device has been considered a demand led solution of the problems of manual application as well as to improve the work efficiency of labor. Applicators of IFDC, IRRI and Chinese model have been tested at BRRI in 1998. All these are found ineffective in the field and do not push the USG inside the soil surface. On the other hand, metering device and skidding mechanism do not work properly and leads to miss the pickup of USG from the hopper resulting missing placement in the field. Under the proposed plan, a new USG applicator will be designed, fabricate, validated in the farmers field to overcome existing problem of manual placing of USG/UMG.

b. Justification for rice transplanter

Due to high cropping intensity, there is a very limited time between harvesting of one crop and sowing/transplanting of the next one. Transplanting and harvesting of crops are the most important agricultural operations which demand considerable amount of labor. The total labor requirement for rice production in 1 hectare of land was 156.2 man-days of which 44.5 man-days were consumed by seeding raising and transplanting which is 28.24% of the total labor requirement (Rahman, 1997). For manual transplanting in rows approximately 400 man-hr/ha labor is required which is roughly 30% of the total labor requirement for rice production (Islam, 1998). The yield loss due to delayed planting were 60.0, 55.4 and 9.0 kg per ha/day in the Boro, Aman and Aus seasons, respectively (Satter, 1999).

Shortage of labor and draught power in agriculture has become serious problem during peak period of planting and harvesting. In this context, farm mechanization with small,

low cost and easily operable farm machinery could lead to make cultivation more profitable and to maximize production.

Shortages of human labour, farmers are compelled to practice delayed planting which results in yield loss. It is therefore essential to adopt the mechanical transplanter to ensure the timeliness in planting. So far, no meaningful attempt has been made to adopt the rice transplanter at farmers' field. Under the proposed plan, 4-row walking type and a 6-row riding type rice transplanter will be collected, modified and tested it in the FMPHT workshop for Bangladesh context and tested in the research field.

Power transplanters were manufactured and marketed in Japan since 1965 (Miura, 1966). A two-row Japanese rice transplanter (AP200) is almost 20 times faster than hand transplanting method and capable of transplanting rice seedling with almost 100% accuracy and negligible missing hills. It needs to rise seeding in trays adaptable for 15-18 days old seedlings. The seedling height, density and soil thickness in seed tray is very important for mechanical transplanting. The seedling height should be 120 mm with 3-4 leaves, 2-4 seedling per square cm and a 2-2.5 cm soil thickness are appropriate for mechanical transplanting. If adequately introduced it may be an appropriate rice transplanting technology for the farmers of the country. Therefore, test and adaptation of mechanical rice transplanter having faster work rate is essential.

8. Sub-project objectives

- To design and development of user friendly manually operated USG applicator
- To modify and improvement of rice transplanter
- To validate and adoption of the developed technology to the end users
- To increase labor efficiency and reduce human drudgery
- To reduce turn-around time and increase the cropping intensity

9. Methodology

i. Approaches

a. Approaches for USG Applicator

USG applicator was designed for two rows application of fertilizer in a single pass using AutoCAD drawing tools. According to design, prototype was fabricated in the research workshop and tested in the lab and BRRI research fields. During test, problems regarding USG dispensing efficiency, USG clogging, furrow opening & covering and depth of placement of USG were collected for further improvement of the applicator. Research station based trials were conducted of the improved applicator. After rectification of the problems that was identified during research based trials, field trials were conducted in the farmers' field. Improved applicator were procured and distributed in the project locations for large scale validations.

b. Approaches for rice transplanter

Two walking and two riding type's rice transplanter were collected as per Govt. Procurement rule. Seedling raising techniques were developed for rice transplanter before field trials. Research station based trials were conducted to identify the operational conditions, machine performance in terms of field capacity, fuel consumptions, spacing of transplanting, missing hills, number of seedling per hills etc. Hands on training on seedling raising were conducted in the farmers' condition for field trials of mechanical rice transplanter. Field trials of mechanical rice transpolanter were conducted in the farmers' field using the farmers' raised seedling. Studies on un-puddle transplanting were also conducted with mechanical rice transplanter. On the basis of finding from field trials, modifications of riding type's rice transplanter were conducted.

c. Project locations

Considering high cropping intensity, accessibility, scarcity of farm labor, rice-wheat-rice cropping pattern and soil type, project locations were selected at different locations of the country namely Rajshahi, Rangpur, Kushtia, Comilla, Habigonj and Netrakona districts. Two upazila from each district was selected with the help of DAE to implement the project activities. Name of upazila are Paba and Godhagari of Rajshahi, Sadar and Mithapukur of Rangpur, Sadar and Kumarkhali of Kushtia, Laksam and Burichong of Comilla, Sadar and Baniachong of Habiganj, Sadar and Purbadhala of Netrakona.

d. Site selection

USG applicator prototype fabrication as per design was conducted in BRRI research workshop. After research based trials, Design of USG applicator was finalized and prototype was fabricated in the workshop and provided to the manufacturer.

Experimental trials were conducted in the BRRI HQ and BRRI R/S research farm to evaluate the USG applicator and rice transplanter. Validation trials and large scale validations were conducted in the project locations in farmers' field. Progressive farmers and representative field was selected with help of DAE considering the ease of accessibility, irrigation facility and farmers interest. At least one bigha of land for both USG applicator and rice transplanter evaluation was selected.

e. Seasons and number of trials

USG Applicator

Season	No. of trials	Comments
Aman/2010	06	Research trials
Boro/2011	13	Research trials
Boro/2012	11	Validation trials
Aman/2012	11	Validation trials
Boro/2013	12	Validation trials
Boro/2013	316	Large scale validation trials
Aus/2013	2	Validation trials
Aman/2013	15	Validation trials

Rice transplanter

Season	No. of trials	Comments
Aus/2011	01	Research trials
Aman/2011	11	Research and Validation trials
Boro/2012	13	Research and Validation trials
Aus/2012	01	Validation trials
Aman/2012	11	Validation trials
Boro/2013	21	Large scale validation trials
Aus/2013	02	Validation trials
Aman/2013	13	Validation trials
Boro/2013	04	Trials for un-puddled condition
Boro/2013	47	Validation trials

ii. Details methodology

I. Methodology for USG Applicartor

a. Design and development of USG Applicator

Available size of urea granule and recommended dose

On the basis of size and weight, granules urea becomes different. Based on size and weight, different urea granules are shown in Appendix-A (Fig. A1).

- 0.9 gm wt. (width: 15 mm and height: 11 mm) granule known as urea supper granule (USG). Three USG are used in one place for Boro rice and 2 nos. for Aus and Aman rice.
- 1.8 gm (width: 18 mm and height: 13 mm) and 2.7 gm wt (width: 20 mm and height: 14 mm) granule known as urea mega granule (UMG). For Aman and Boro rice cultivation, one UMG of 1.8 gm and 2.7 gm are used in one place respectively.

Constraint to design USG applicator

Shape of the granule is important to design the metering device. Because of oval shape of the granule with barb that makes bridge in the tank (Appendix-A, Fig. A2). Soil condition is another constraint to design an applicator because of different in different locations.

Materials and Method

- MS sheet, flat bar, angle bar, shaft bar, GI pipe, Nuts and Bolts and Granular urea
- Design the applicator using AutoCAD Program and a Prototype was fabricated in the FMPHT divisional research workshop.

Design considerations of the applicator

The applicator was designed using the following design considerations.

- Line to line and plant to plant spacing should be 20 cm
- Depth of placing should be 6-8 cm
- The applicator should be simple and easy both in operation and maintenance
- Locally available materials should be used to minimize the fabrication cost.
- Application capacity should be accepted by the farmers
- During operation, it should be trouble free.

Design

Width of the applicator

The applicator was designed for double row operation considering 20 cm line to line spacing thus distance between two skids is 40 cm (center to center). By single pass of the applicator, 80 cm effective width is covered (Fig. 1).

Metering device

Cup type metering device was utilized to collect USG/UMG from tank and dispense to the output channel. The diameter of the metering plate was 18.12 cm. Five cups were used in each round plate considering the diameter of the drive wheel. Diameter and depth of the holes of the cup were maintained 1.9 cm and 0.6 cm respectively based on size and diameter of the granules (Fig. 2). Every cup was assembled in the metering plate at 5 degree inclined towards forward direction for easy collection of UMG from tank. Metering device was connected directly to the drive wheel.

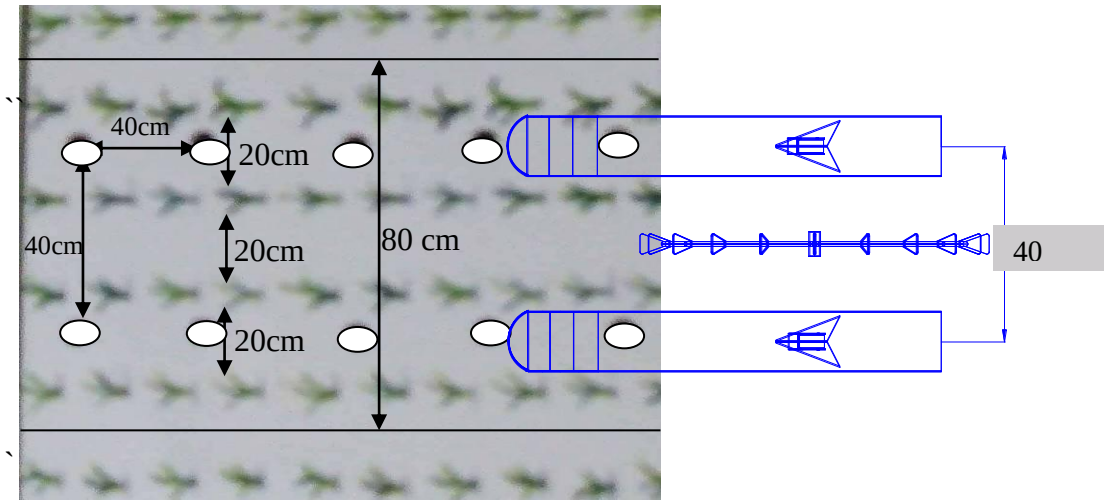

Fig 1. Arrangement of the two skids driving wheel with line spacing

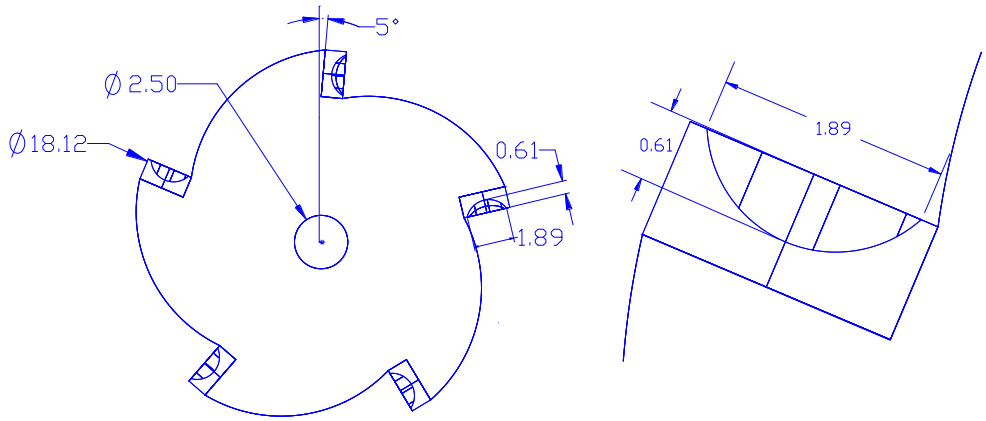

Fig 2. Metering device with cups and plate arrangement

Drive wheel

Designed diameter of the drive wheel was 63.69 cm considering the 200 cm periphery of the drive wheel. So, by one rotation, it covered 200 cm horizontal distance (Fig. 3). Metering device of the applicator also completed one rotation with one rotation of the drive wheel because of direct coupling. Five cups were assembled into the metering plate. As a result, 5 granules were collected from tank and dispensed in 200 cm distance with one rotation of the metering device that was made 40 cm spacing between granule to granule (Fig. 3).

Lugs of the drive wheel

Lugs were used in the drive wheel to develop traction during field operation. The amount of traction was directly related with the length and width of the lug, soil condition and weight of the applicator. Optimum size (width=4.25 cm and height=5.0 cm) was determined by trial error basis considering the different soil condition and weight of the applicator (Fig. 4). A total of 20 lugs were used for smooth operation of the applicator in the fields (Fig.5).

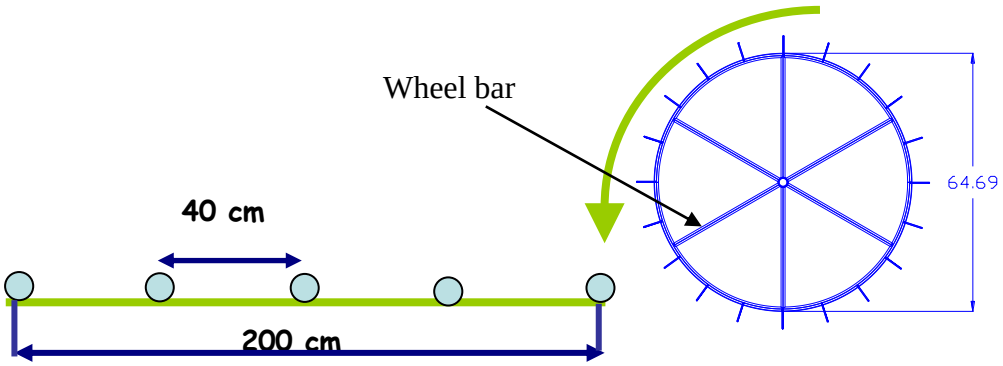

Fig 3. Drive wheel of the applicator

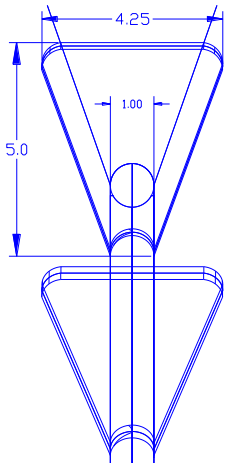

Fig 4. Front view of an individual lug

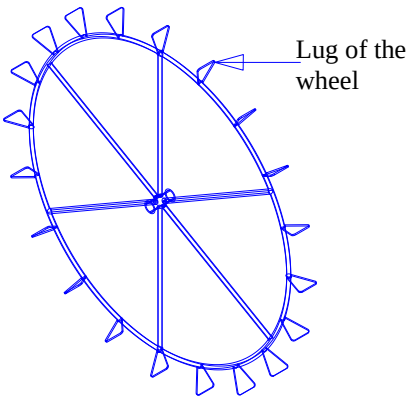

Fig 5. Isometric view of lugs with drive wheel

USG/UMG granules Tank

Granules holding tanks of the applicator were designed to supply the granules to the cups of the metering device properly considering the angle of repose of the USG granules. Angle of repose of the USG granules (2.7 gm size) was found 30 degree.

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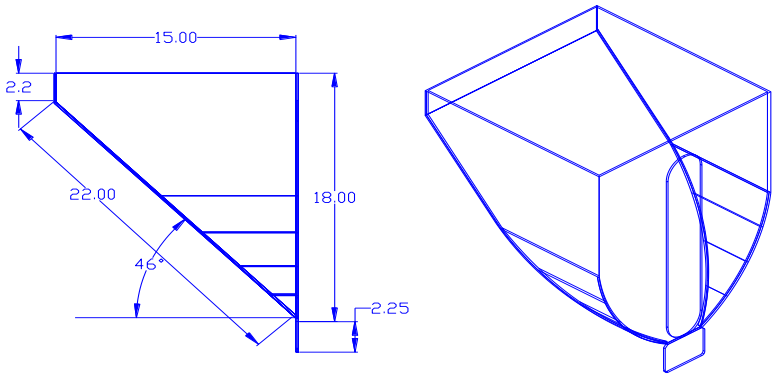


Fig 6. Side and isometric view of the granules tank

The angle of inclination and length of the sliding side, height and width of the tank was 46 degree, 22 cm, 18 cm and 15 cm respectively (Fig. 6). The middle edge of the granules influenced the angle of repose positively.

Skid and Furrow opener

Penetration of the applicator was protected due to use of skid and helps to skidding. 25 degree skidding angle was used in the apex of the skid (Fig. 7). The size of the skid was designed based on cone penetration resistance of the soil. Length and width of the skid was critically selected 72.00 and 12 cm respectively. So, area of skid was found 864 cm^2 that could resist the penetration of the applicator in different soil conditions. Furrow opener of the applicator was connected at the bottom of the skid maintaining the sliding angle 26 degree.

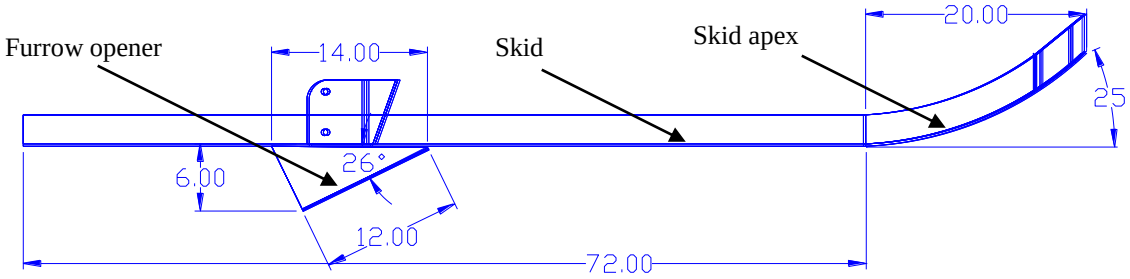


Fig 7. Side view of the skid and furrow opener

Height (6.0 cm) and length (12.0 cm) of the sliding side of the furrow opener was designed in such way that the granules dispensed easily to the field without clogging and protected muddy soil from entering into the opener (Fig. 7).

Output channel

Output channel of the applicator was connected to granule tank and furrow opener that conveyed the collected granules to the field (Fig. 8). Changing the height of the furrow opener maintaining the 26 degree sliding angle (Fig. 7), depth of granule placement can be changed. The lower part of the channel was connected to skid with a rectangular holder at 20 degree inclined.

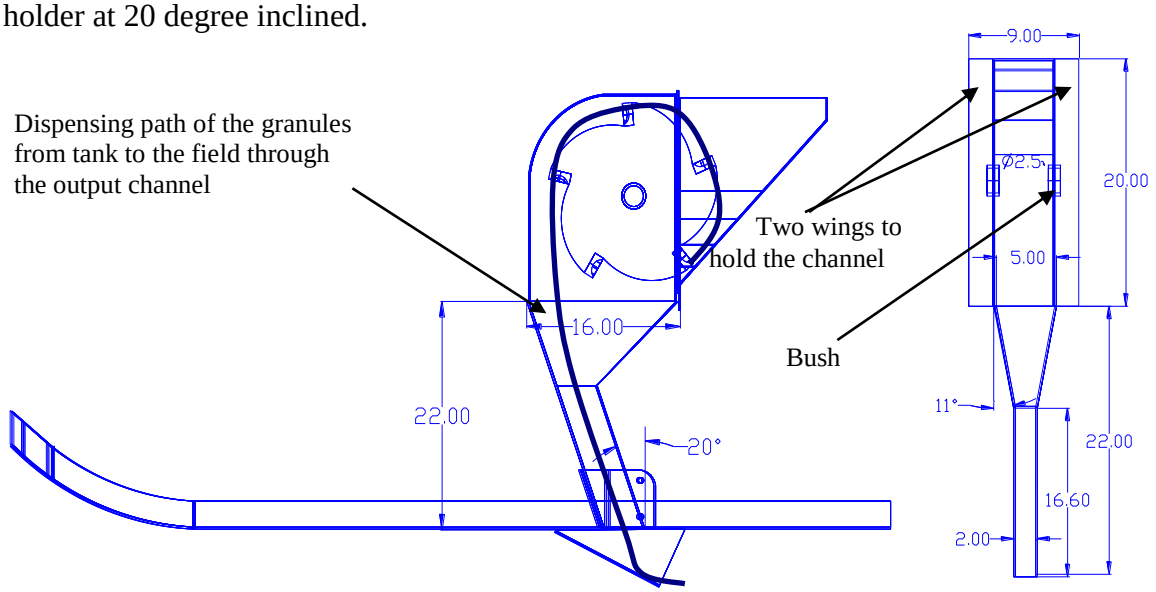


Fig 8. Side and front view of the output channel of the applicator

Covering mechanism

Simple technique was exercised to cover the furrow as well as dispensed granules. Additional plate as per designed shown in the figure was assembled as covering device at the rear of the skid. Depth of the covering device was maintained 4.5 cm by inclining in three stages which was shorter than the depth of USG placement into the soil (Fig. 9). As a result, the placed granules were not disturbed by the covering device.

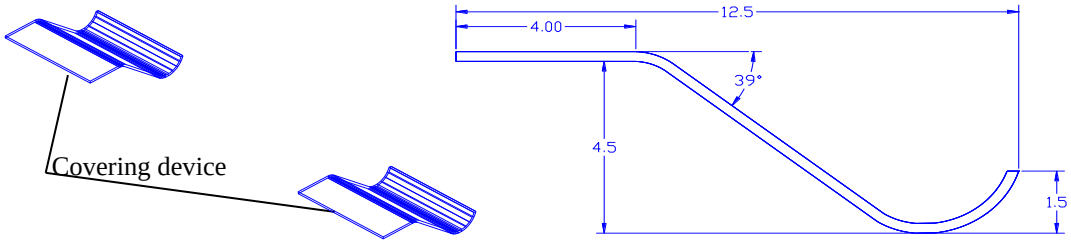


Fig 9. Isometric and side view of the covering device

Granules protecting mechanism

Spring and cantilever type arrangement was applied to protect the granules dispensing from tank in between gaps of the two cups (Fig. 10 & 11). When one cup collected granule and moved forward with the rotation of the drive wheel then door was opened before reaching the next cup of the metering device. This applied mechanism protects the granules with the apex of the plate. When a cup was entered into the granules tank, the lever was moved downward with the pressure of the cup and again backed to the original position after forward motion of the cup. Soft spring was utilized to avoid the heavy friction between cups and lever.

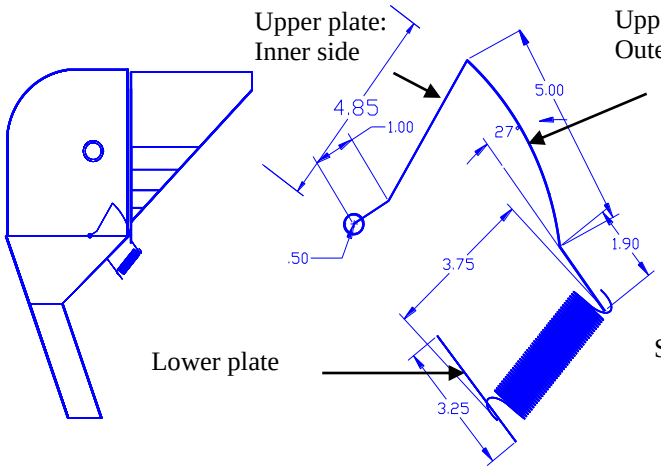


Fig 10. Granules protecting mechanism

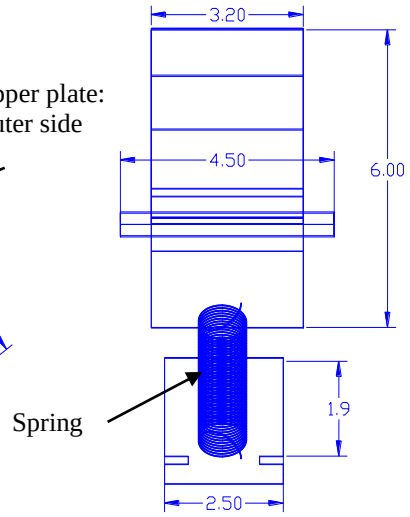
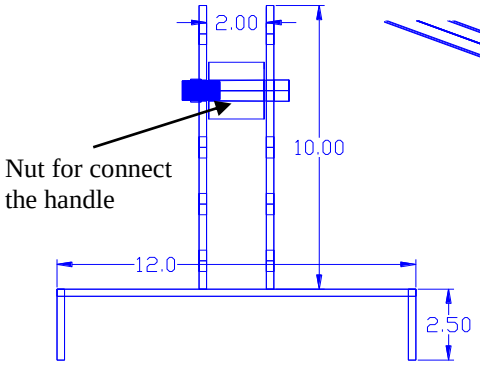


Fig 11. Side and front view of granules protecting mechanism

Handle holder

Simple cantilever type handle holder was designed for the handle on the skid at 20 cm distance from end of the skid. There were five options to change the height of the handle as suited by the height of the operator.



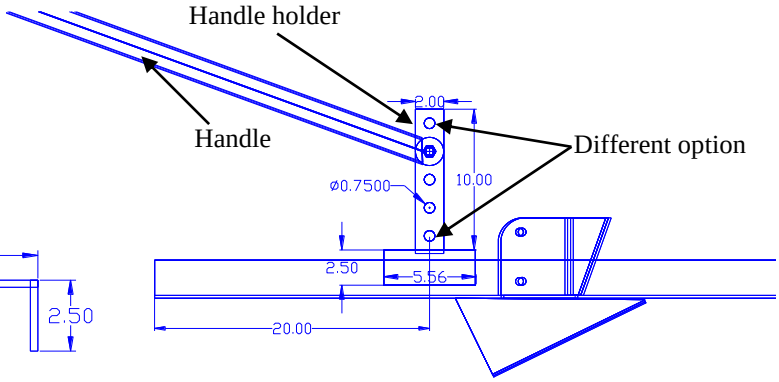


Fig 12. Front view of the handle holder **Fig 13. Side view of the handle holder**

Total height of the holder from bottom of the skid, spaced between two levers, width of the lever, hole diameter and distance between two holes were made use of 12.5, 2.0, 2.0, 0.75 and 2.00 cm respectively (Fig. 12 & 13).

Complete view of the applicator

The complete view of the applicator that was designed using AutoCAD engineering tools mentioned below as side projection (Fig.14).

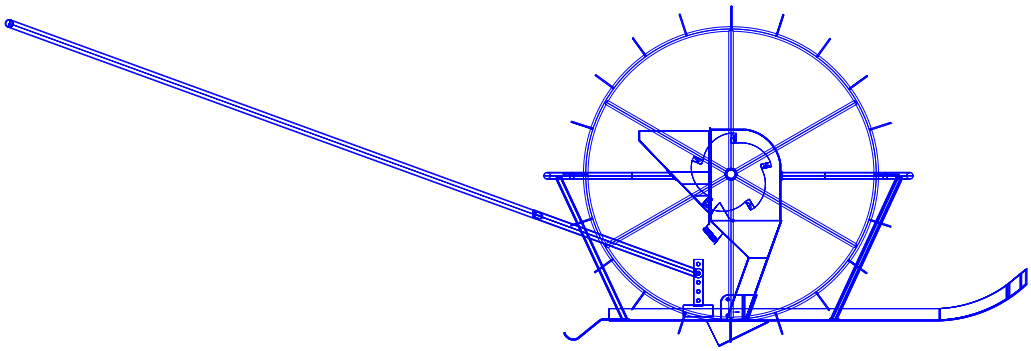


Fig 14. Complete side view of the applicator

Performance test of the applicator

BRRI USG applicator was tested using urea mega granules (UMG: 2.7gm) in both laboratory and field condition to observe the performance. During test, the following data were collected:

- USG/UMG dispensing efficiency (%)
- Accuracy of placement between rows (%)
- Depth of placement (cm)
- Walking speed (km/hr)
- Field capacity (ha/hr)

b. Improvement of BRRI USG Applicator

BRRI USG applicator was re-designed for incorporating the adjustable mechanism with the facility of 18, 20 and 22 cm line to line spacing transplanted rice field. To reduce the total weight of the applicator, skid and drive wheels are converted from metallic to plastic materials. Prototype was fabricated in the Farm Machinery and Postharvest Technology (FMPHT) divisional research workshop. Design the modified applicator using AutoCAD Programming tools and Prototypes was fabricated in the FMPHT divisional research workshop.

Design considerations for improvement of the BRRI USG Applicator

Improvement was done on the adjusting mechanism of the applicator. During design, the following criteria were collected:

- Ease of adjusting
- Ease of operations
- Minimum time of adjusting

Skid, covering mechanism and drive wheel of the USG Applicator were re-designed for plastic materials and converted from metallic to plastic materials. During design, the following criteria were taken in consideration:

- Enough strength for muddy soil
- Ease of operations
- Properly coverage of the dispensed granules

Performance test of the improved applicator

Improved prototypes of BRRI USG applicator was tested using urea mega granules (UMG: 2.7gm) in both laboratory and field condition to observe the performance. During test, the following data were collected:

- USG/UMG dispensing efficiency (%)
- Depth of placement (cm)
- Accuracy of placement between rows (%)
- Walking speed (km/hr)
- Field capacity (ha/hr)

Design of the improved applicator

The applicator was designed with the help of AutoCAD engineering tools considering the design consideration. The complete design view of the modified version is given in Fig. 15.

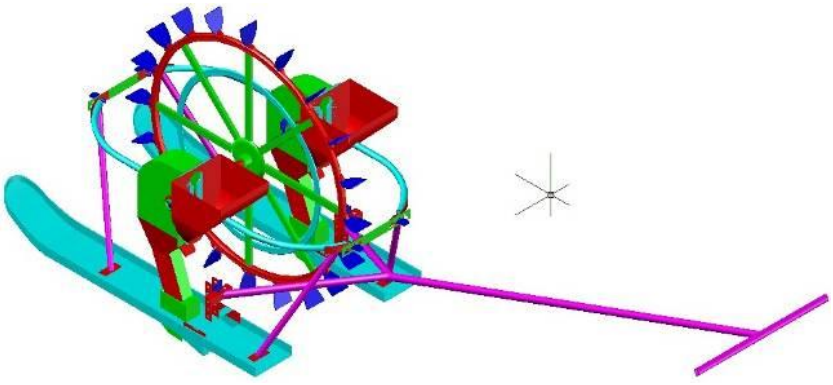


Fig. 15. BRRI modified USG Applicator

Metering device

In both 1st and modified version of the applicator, cup type metering device was used to collect USG/UMG from tank and dispense to the output channel. The outer diameter of the metering plate is 17.9 cm. Five cups is used in each round plate considering the diameter of the drive wheel. Diameter and depth of the holes of the cup were maintained 2.0 cm and 0.5 cm respectively based on size and diameter of the granules (Fig. 16). Metering device was connected directly to the drive wheel.

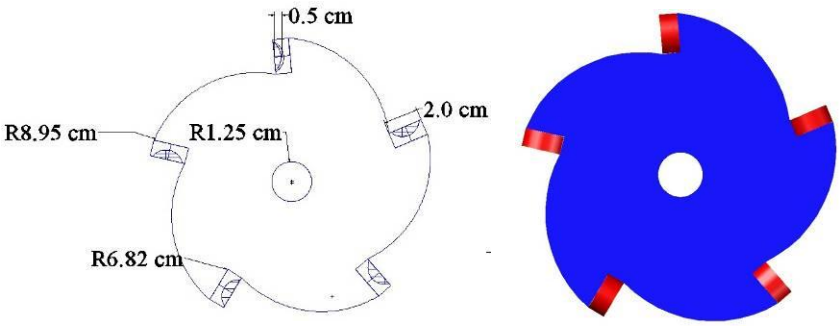


Fig. 16. Metering plate of the modified applicator

Granule tank

Granules holding tanks of the applicator were designed to supply the granules to the cups of the metering device properly considering the angle of repose of the USG granules. Angle of repose of the USG granules (2.7 gm size) was found 30 degree. The angle of inclination and length of the sliding side, height and width of the tank was 46 degree, 22 cm, 18 cm and 15 cm respectively (Fig. 17). Granule tank is same in both type applicators.

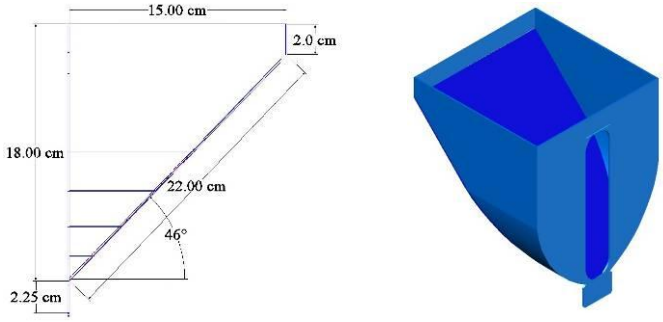


Fig 17. Side and isometric view of the granules tank

Skid

Penetration of the applicator was protected due to use of skid and helps to skidding. As per design, drive wheel and skid was made by plastic materials. In the first version, metallic skid was used for operating in the muddy filed. Total weight was more, size was large and fabrication in the workshop was difficult of the skid of 1st version. The skid was re-designed based on cone penetration resistance of the soil. Length of the skid was reduced critically from 100.00 cm to 81.00 (Fig. 18).

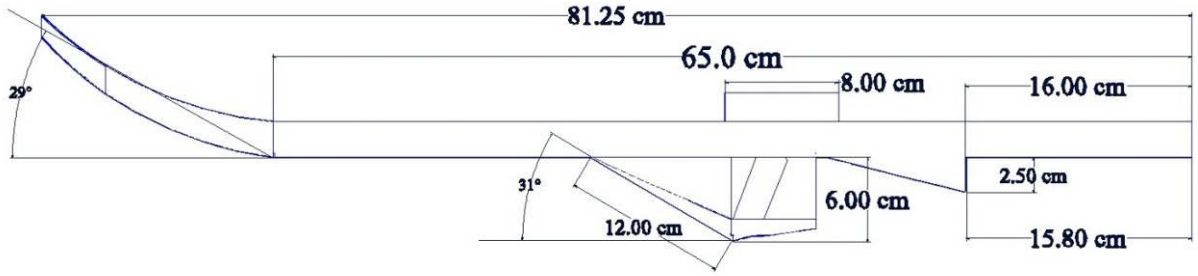


Fig 18. Side view of the skid and furrow opener of the modified applicator

29 degree skidding angle was used in the apex of the skid. Furrow opener of the applicator was connected at the bottom of the skid maintaining the sliding angle 31 degree. Height (6.0 cm) and length (12.0 cm) of the sliding side of the furrow opener was designed in such way that the granules dispensed easily to the field without clogging and protected muddy soil from entering into the opener (Fig. 18).

Furrow covering mechanism

Additional plate was added as covering device at the rear of the skid in the first version. Depth of the covering device was maintained 4.5 cm which was shorter than the depth of USG placement into the soil. As a result, the placed granules were not disturbed by the covering device. But there was problem of entering water into the furrow before covering. The water flows displaced the placed granules before covering. Considering this problem, covering device was used at the vicinity of the granule dispensing path. The distance between covering device and granule dispensing path is 16.0 cm which was 35.0 cm in the first version. As a result, dispensing granule is not displaced from the point by counter water flow.

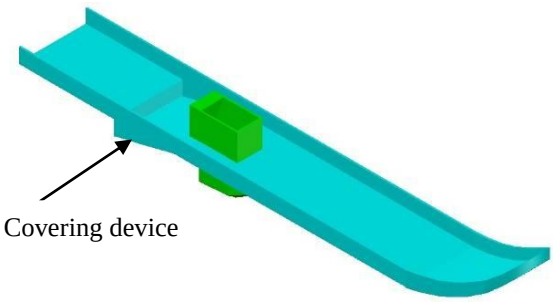


Fig 19. Plastic made Skid of the modified applicator

Driving wheel

As per design, drive wheel was made by plastic materials. The comparative view of the drive wheels is given as follows. Because of plastic conversion, it is easy to fabrication, more durable and less weight compare to metallic one which untimely helps to reduce total weight of the applicator (Fig. 20).

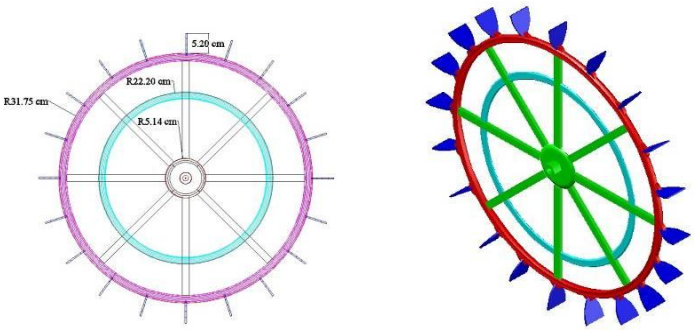


Fig 20. Plastic made drive wheel of the modified applicator

Fabrication of the applicator

As per design, the applicator was assembled in the divisional workshop. Total weight of the applicator was reduced from 10.0 kg to 7.5 kg. As a result, it was found suitable to carry to the field, turning at the end of field and operating in the muddy field. Complete views of the modified and 1st version of applicator are shown in Appendix-A, Fig A3 & A4.

Applicator operation

There have three options to adjust the spacing of the applicator considering the line to line distance of the transplanted rice. Two nuts of the main axle, four nuts of the frame and two nuts of the handle have to be adjusted among the three options of 18 cm, 20 cm or 22 cm considering the existing line spacing of the transplanted rice before field operation (Appendix-A and Fig. A5).

Handle height also have to be adjusted in such way that the operator feels comfort to operate the applicator and covering device remain in contact with the soil horizontally. It is always operated by pushing force. If it is pulled during operation, the dispensed channel becomes blocked by muddy soil. As a result, granule will not be placed.

c. Research station based trials of USG Applicator during Aman/2010

BRRI USG applicator (fixed model), USG and prilled urea, scale, rope, tape, stopwatch, calculator, weight balance etc were used during the study.

- Varieties : BRRI dhan49 and BRRI dhan33
- Seedling age : 35 to 40 days at transplanting time
- Spacing: 20×20 cm
- Size of USG = 1.8 gm (mega size)
- Date of USG application : After 7-10 days of transplanting

During performance study in different locations, the following treatments were applied:

- T_1 = USG application in the field by USG applicator
- T_2 = USG application in the field manually
- T_3 = Prilled urea application by hand broadcasting

Design: RCBD

Fertilizer does in terms of USG was same for T_1 and T_2. Prilled urea was broadcasted in T_3 by hand on the basis of BRRI recommendation dose. Others fertilizer and management practices was the same for all treatments.

Data were collected

- Time required to apply urea in the field (hr/ha) for all treatments
- Capacity of BRRI USG applicator and manual application of USG
- Plant height and tiller no at ATS, MTS and MS
- Uniformity of the plants height
- Yield and yield components

Season: Aman, 2010

Location/site

Total number of 6 field trails was conducted in BRRI research farm, Gazipur and BRRI regional station of Kushtia, Rajshahi, Rangpur, Comilla and one in farmer's field of Netrakona to observe the field performance of the applicator.

Table 1. General information of the experimental plots, Aman/2010

Location	Variety	Area (decimal)	Fertilizer rate (kg/ha)						D/T	D/USG App.	Date of harvesting
			TSP	MP	Gyp.	$Znso_4$	Prilled Urea	USG			
BRRI R/S, Kushtia	BRRI Dhan49	35	52	60	35	5	210.0	118.0	24/07/10	03/08/10	29/11/10
BRRI R/S, Rajshahi	BRRI Dhan49	36	62	80	45	5	172.0	118.0	05/08/10	16/08/10	15/11/10
BRRI, Gazipur	BRRI Dhan49	65	76	90	45	5	172.0	118.0	10/08/10	22/08/10	25/11/10
Netrakona	BRRI Dhan33	80	65	70	40	10	170.0	118.0	10/08/10	23/08/10	10/11/10
BRRI R/S, Comilla	BRRI Dhan49	35	75	100	60	10	210.0	118.0	20/08/10	30/08/10	01/12/10
BRRI R/S, Rangpur	BRRI Dhan49	35	80	100	60	10	175.0	118.0	14/08/10	25/08/10	30/11/10

d. Field trials of USG Applicator during Boro/2011

BRRI USG applicator (fixed model), USG and prilled urea, scale, rope, tape, stopwatch, calculator, weight balance etc were used during the study.

- Varieties : BRRI dhan49 and BRRI dhan33
- Seedling age : 35 to 40 days at transplanting time
- Spacing: 20×20 cm
- Size of USG = 2.7 gm (mega size)
- Date of USG application : After 7-10 days of transplanting

Treatments

During performance study in different locations, the following treatments were applied:

- T_1 = USG application in the field by USG applicator
- T_2 = USG application in the field manually
- T_3 = Prilled urea application by hand broadcasting

Design: RCBD

Fertilizer does in terms of USG was same for T_1 and T_2. Prilled urea was broadcasted in T_3 by hand on the basis of BRRI recommendation dose. Others fertilizer and management practices was the same for all treatments.

Data were collected

- Time to apply urea fertilizer/USG in the plot (hr/ha) for all treatments
- Capacity of BRRI USG applicator and manual application of USG
- Yield and yield components

Season: Boro, 2011

Location/site

Total 13 field trials were conducted in different lactations of the country during Boro/2011 season. Among these, 12 field trails was conducted in the farmer's field and one experiment was in BRRI R/S, Habiganj. The locations were Rajshahi (Khasba, Paba), Rangpur (Sutrapur and Akkelpur, Sadar), Kushtia (Baria, Sadar and Tarapur, Kumarkhali), Comilla (Kharataiya, Burhicang and Narpati, Laksam), Habigonj (Richi, Sadar and Cturango-rayer-para, Baniacang) and Netrakona (Challisha, Sadar and Gohalakanda, Purbadhala).

Table 2. General information of the experimental plots, Boro/2011

Location	Variety	Area (decimal)	Fertilizer rate (kg/ha)						D/T	D/USG App.	Date of harvesting
			TSP	MP	Gyp.	$Znso_4$	Prilled Urea	USG			
Sadar, Kushtia	BRRI Dhan29	100	100	120	70	15	285	168	30/12/10	10/01/10	07/05/11
Kumarkhali Kushtia	BRRI Dhan29	60	100	120	70	15	285	168	04/01/11	11/01/11	15/05/11
Sadar, Habiganj	BRRI Dhan29	40	90	100	60	12	280	168	10/01/11	19/01/11	15/05/11
Baniacang Habiganj	BRRI Dhan29	33	90	100	60	12	280	168	02/02/11	14/02/11	09/05/11
BRRI R/S Habiganj	BRRI Dhan29	24	90	100	60	12	280	168	10/01/11	20/01/11	10/05/11
Burhicang Comilla	BRRI Dhan29	32	110	125	75	18	340	168	28/01/11	15/02/11	18/05/11
Laksam Comilla	BRRI Dhan29	35	110	125	75	18	340	168	27/01/11	09/02/11	19/05/11
Sadar Rangpur	BRRI Dhan28	33	100	120	65	15	280	168	25/01/11	05/02/11	20/05/11

Location	Variety	Area (decimal)	Fertilizer rate (kg/ha)						D/T	D/USG App.	Date of harvesting
			TSP	MP	Gyp.	$Znso_4$	Prilled Urea	USG			
Sadar Rangpur	BRRI Dhan29	33	100	120	65	15	280	168	24/01/11	06/02/11	21/05/11
Sadar Netrakona	BRRI Dhan29	33	100	120	70	15	285	168	13/01/11	25/01/11	27/05/11
Purbadhala Netrakona	BRRI Dhan29	33	100	120	70	15	285	168	25/01/11	05/02/11	01/05/11
Paba Rajshahi	BRRI Dhan29	33	100	120	75	18	300	168	12/02/11	24/02/11	12/05/11

e. Field trials of USG Applicator during Boro/2012

Same as Boro/2011 except following

- Varieties : BRRI dhan29 and BRRI dhan28
- Seedling age : 40 to 45 days at transplanting time

Location/site

Total number of 10 field trails was conducted in different location to observe the field performance of the applicator. The locations were Kumarkhali, Kushtia (01); Sadar, Netrakona (01); Laksam, Comilla (01); Purbadhala, Netrakona (01); Burichang, Comilla (01); Sadar, Habiganj (01); Sadar, Rangpur (01); Paba, Rajshahi (01); Godagari, Rajshahi (01); Mithapukur, Rangpur (01).

Table 3. General information of the experimental plots, Boro/2012

Location	Variety	Area (decimal)	Prilled Urea (kg/ha)	USG (kg/ha)	D/T	D/USG App.	Date of harvesting
Kumarkhali Kushtia	BRRI Dhan29	20	270	167.5	12/01/12	16/01/12	23/05/12
Sadar Netrakona	BRRI Dhan29	50	270	164.0	17/01/12	24/01/12	18/05/12
Laksam Comilla	BRRI Dhan28	30	250	164.0	18/01/12	29/01/12	05/05/12
Purbadhala Netrakona	BRRI Dhan29	20	270	168.0	30/01/12	30/01/12	11/05/12
Burichang Comilla	BRRI Dhan29	20	270	167.0	01/02/12	08/02/12	15/05/12
Sadar Habiganj	BRRI Dhan29	50	270	169.0	15/02/12	24/02/12	20/05/12
Sadar Rangpur	BRRI Dhan29	30	270	162.8	10/02/12	14/02/12	24/05/12
Paba Rajshahi	BRRI Dhan29	20	270	168.0	11/02/12	16/02/12	05/05/12
Godagari Rajshahi	BRRI Dhan28	20	250	165.0	18/01/12	24/01/12	06/05/12
Mithapukur Rangpur	BRRI Dhan28	20	250	164.0	05/02/12	13/02/12	24/05/12

f. Field trials of USG Applicator during Aman/2012

Plastic version of USG Applicator was used to conduct the field trials in different project locations during Aman/2012 season. 30-35 days older seedling was used in this experiment. Land was prepared and leveled by power tiller. After land preparation, the field was kept two days for soil settlement and transplanting. 0.5 cm standing water was maintained during field operation. After 3-4 days of transplanting, field trials were conducted. Treatments were T_1= USG application by machine and T_2=Prilled urea application. In both treatments, fertilizer except urea, irrigation, crop management practices were same. . In case of USG application, 20x20 cm spacing was used to conduct the trials whereas farmer's practices were used for prilled urea application.

USG Applicator, USG, scale, rope, tape, stopwatch, calculator, weight balance etc were used during the study.

- Varieties : BRRI dhan49, BRRI dhan33 and BINA dhan7
- Seedling age : 30-35 for transplanting
- Spacing: 20 ×20 cm for machine and farmers practices for prilled urea.

Data were collected

- Performance parameters of the USG Applicator
- Yield and yield components

Season: Aman/2012

Location/site

Total number of 11 field trails was conducted in different location to observe the field performance of the mechanical rice transplanter. The locations were Laksam , Comilla; Burichang, Comilla; Nakla, Shrerpur; Sadar, Kushtia; Kumarkhali, Kushtia; Purbadhala, Netrakona; Sadar, Netrakona Sadar, Rangpur; Mithapukur, Rangpur; Sadar, Habiganj and BRRI, Gazipur.

Table 4. General information of the field trials during Aman/2012

Place	Variety	Area (decimal)	Date of transplanting	Date of USG application	Date of harvesting
Laksam, Comilla	BRRI dhan49	33	15/7/12	19/7/12	03/11/12
Burichang, Comilla	BRRI dhan49	35	17/7/12	20/7/12	04/11/12
Nakla, Shrerpur	BRRI dhan49	29	25/7/12	28/7/12	05/11/12
Sadar, Kushtia	BRRI dhan49	26	28/7/12	30/7/12	06/11/12
Kumarkhali Kushtia	BINAI dhan7	39	30/7/12	31/7/12	05/11/12
Purbadhala, Netrakona	BRRI dhan49	32	02/08/12	03/08/12	11/11/12
Sadar, Netrakona	BRRI dhan33	41	02/08/12	04/08/12	01/11/12
Sadar, Rangpur	BRRI dhan49	33	05/08/12	07/08/12	12/11/12
Mithapukur, Rangpur	BRRI dhan49	37	05/08/12	08/08/12	12/11/12
Sadar, Habiganj	BRRI dhan49	26	05/08/12	09/08/12	13/11/12
BRRI, Gazipur	BRRI dhan49	33	08/08/12	10/08/12	14/11/12

g. Field trials of USG Applicator during Boro/2013

Plastic version of USG Applicator was used to conduct the field trials in different project locations during Boro/2013 season. 22 to 28 days old seedling with 3-4 leaves was used in this experiment. Land was prepared and leveled by power tiller. After land preparation, the field was kept two days for soil settlement and transplanting. 0.5 cm standing water was maintained during field operation. After 3-4 days of transplanting, field trials were conducted. Treatments were T_1= USG application by machine and T_2=Prilled urea application. In both treatments, fertilizer except urea, irrigation, crop management practices were same. . In case of USG application, 20x20 cm spacing was used to conduct the trials whereas farmer's practices were used for prilled urea application.

USG Applicator, USG, scale, rope, tape, stopwatch, calculator, weight balance etc were used during the study.

- Varieties : BRRI dhan29, BRRI dhan28 and BRRI dhan50
- Seedling age : 22 to 28 for transplanting
- Spacing: 20 ×20 cm for machine and farmers practices for prilled urea.

Data were collected

- Performance parameters of the USG Applicator
- Yield and yield components

Season: Boro/2013

Location/site

Total number of 21 field trails was conducted in different location to observe the field performance of the USG Applicator. The locations were Jatrapasha, Habiganj; HislakorPurbapara, Kumarkhali; HislakorPashimpara, Kumarkhali; HislakorDakkinpara, Kumarkhali; Hislakor Primary school area, Kumarkhali; Sutrapur, Rangpur; Gohalakanda, Purbadhala; Mohismara, Burichang, Comilla-1; Gazipur, Burichang, Comilla-1; Ratanpur, Sadar, Habiganj; Sutrapur, Rangpur; Challisha, Sadar, Netrakona; Paba, Rajshahi-1; Paba, Rajshahi-2; Battail, Sadar, Kushtia; Purbadhala, Netrakona; Shripur, Laksam, Comilla; Gazipur, Burichang, Comilla-2; Baniachang, Habiganj; Joyrampur, Mithapukur, Rangpur-1 and Joyrampur, Mithapukur, Rangpur-2.

Table 5. General information of the USG Applicator field trials during Boro/2013

Place	Variety	Area (decimal)	Date of transplanting	Date of operation	Date of harvesting
Jatrapasha, Habiganj	BRRI dhan28	34	25/02/2012	01/03/13	12/05/213
Hislakor-1,Kumarkhali	BRRI dhan29	33	16/01/2013	21/01/13	23/05/2013
Hislakor-2, Kumarkhali	BRRI dhan29	39	08/01/2013	13/01/13	21/05/2013
Hislakor-3, Kumarkhali	BRRI dhan29	32	24/01/2013	29/01/13	30/05/2013
Hislakor-4, Kumarkhali	BRRI dhan29	25	25/01/2013	29/01/13	30/05/2013
Sutrapur, Rangpur	BRRI dhan28	35	11/02/2013	15/02/13	25/05/2013
Gohalakanda, Purbadhala	BRRI dhan28	38	28/02/2013	04/03/13	19/05/2013
Burichang-1, Comilla	BRRI dhan28	32	02/02/2013	05/02/13	27/05/2013
Burichang-2, Comilla	BRRI dhan28	41	07/02/2013	11/02/13	31/05/2013
Sadar, Habiganj	BRRI dhan28	33	10/02/2013	14/02/13	22/05/2013
Sutrapur, Rangpur	BRRI dhan28	34	08/02/2013	13/02/13	26/05/2013
Sadar, Netrakona	BRRI dhan29	27	11/02/2013	16/02/13	23/06/2013
Paba-1, Rajshahi	BRRI dhan50	37	14/02/2013	18/02/13	09/06/2013
Paba-2, Rajshahi	BRRI dhan50	45	15/02/2013	20/02/13	09/06/2013
Sadar, Kushtia	BRRI dhan28	33	01/03/2013	06/03/13	22/06/2013
Purbadhala, Netrakona	BRRI dhan29	44	12/02/2013	16/02/13	14/06/2013
Laksam, Comilla	BRRI dhan28	33	01/01/2013	05/01/13	28/04/2013
Burichang-3, Comilla	BRRI dhan28	32	16/02/2013	21/02/13	04/06/2013
Baniachang-3, Habigonj	BRRI dhan29	33	05/01/2013	09/01/13	12/05/2013
Mithapukur-1, Rangpur	BRRI dhan28	28	09/02/2013	14/02/13	25/05/2013
Mithapukur-2, Rangpur	BRRI dhan28	27	16/02/2013	22/02/13	20/05/2013

II. Methodology for rice transplanter

a. Research station based trials of mechanical rice transplanter during Aus/2011

Korean made walking and riding type mechanical rice transplanter was tested in BRRI research field during T. Aus, 2011 using BR26. During test, flexible plastic tray (58 x 28 x 2.5 cm) was used to raise seedling for the transplanter. 12 days older seedling with 3-4 leaves was used in this experiment. Land size of the experimental plot was 375 m^2. After land preparation, the field was kept two days for soil settlement. 1-2 cm standing water was maintained during field operation. The technical specifications are presented in the following Table 6 and 7. The following data were collected during trials

- Seedling per hill
- Missing hill
- Floating seedling
- Walking speed
- Planting depth
- Age and number of leaves of seedling
- Field capacity

Table 6. Specification of Walking Type Rice Transplanter

Country of Origin			South Korea
Model			DP480
Dimensions	Overall length (mm)		2385
	Overall width (mm)		1530
	Overall height (mm)		870
	Overall weight (kg)		160
	Type		4-stock, air-cooled OHV gasoline
	Displacement (CC)		147
	Maximum output (kW/rpm)		3/1800
	Fuel tank capacity (L)		3.4
	Starting method		Recoil
Traveling Section	Steering		Hydraulic power steering mode
	Wheel type		Rubber lug wheel
	Gearshift	Forward	2 speeds
		Reverse	1 speed
Transplanting Section	Transplanting mechanism		Rotary
	Number of rows		4
	Transplanting distance (cm) (row to row)		30
	Transplanting distance (cm) (plant to plant)		11,13,15
	Planting pitch control		Adjustable
	Transplanting speed (m/sec)		0.6 to 1.0

Table 7. Specification of Seating/Riding Type Rice Transplanter

Country of Origin			South Korea
Model			S3-680
Type			Ride on Type
Dimensions	Overall length (mm)		3120
	Overall width (mm)		2140
	Overall height (mm)		1655
	Overall weight (kg)		620
	Type		4-stock, air-cooled OHV gasoline
	Displacement (CC)		437
	Maximum output (kW/rpm)		10.5/3600
	Fuel tank capacity (L)		15 - 20
	Starting method		Electric motor start mode
Traveling Section	Steering		Hydraulic power steering mode
	Tires	Front	Anti-puncture tire
		Diameter (mm)	650
		Rear	Solid rubber
		Diameter (mm)	900
	Gearshift	Forward	2 speeds (Steeples variable speed)
		Reverse	1 speed

Transplanting Section	Transplanting mechanism	Rotary type
	Number of rows	6
	Transplanting distance (cm) (row to row)	30
	Transplanting distance (cm) (plant to plant)	14,16, 18, 20
	Planting pitch control	Adjustable
	Planting depth control	Adjustable
	Planting depth (cm)	0.8 – 4.4
	Number of spare seedling rack	6
	Transplanting speed (m/sec)	0 to 1.36

b. Field trials of rice transplanter during Aman/2011 season

Korean made walking and riding type mechanical rice transplanter was used in this study. Seedling was raised in plastic tray (58 x 28 x 2.5 cm). 18-25 days older seedling with 3-4 leaves was used in this experiment. Land was prepared and leveled by power tiller. After land preparation, the field was kept two days for soil settlement. 0.5 cm standing water was maintained during field operation.

Mechanical rice transplanter, seedling raised on tray and polythene sheet, scale, rope, tape, stopwatch, calculator, weight balance etc were used during the study.

- Varieties : BRRI dhan49 and BRRI dhan32
- Seedling age : 20 to 26 for machine transplanting and 30 days for hand transplanting
- Spacing: 30 ×15 cm for machine and 20 x 15 cm for hand.

During performance study in different locations, the following treatments were applied:

- T_1 = Mechanical transplanting
- T_2 = Manual transplanting

Fertilizer and management practices were the same for all treatments.

Data were collected

- Performance parameters of the mechanical rice transplanter
- Yield and yield components

Season: Aman/2011

Location/site

Total number of 10 field trails was conducted in different location to observe the field performance of the applicator. The locations were Kumarkhali, Kushtia ; Sadar, Kushtia; Rajendrapur, Sadar, Netrakona; Challisha, Sadar, Netrakona; Laksam, Comilla; Purbadhala, Netrakona; Burichang, Comilla; Sadar, Rangpur; Paba, Rajshahi and Mithapukur, Rangpur

c. Field trials of rice transplanter during Boro/2012

Seedling was prepared in the farmers' field/yard with proper instruction to conduct the trials. Farmers prepared their seedling both on polythene sheet and plastic tray. Seedling from polythene sheet was cut using metallic frame similar with plastic tray in size. Before field operation, discussion session was arranged with the help of DAE.

- Varieties : BRRI dhan29 and BRRI dhan28
- Seedling age : 20 to 28 for machine transplanting and 40 days for hand transplanting
- Spacing: 30 ×15 cm for machine and 20 x 15 cm for hand.

During performance study in different locations, the following treatments were applied:

- T_1 = Mechanical transplanting
- T_2 = Manual transplanting

Fertilizer and management practices were the same for all treatments.

Data were collected

- Field performance parameters of the transplanter
- Yield and yield components

Season: Boro/2012

Location/site

Total number of 11 field trails was conducted in different location to observe the field performance of the applicator. The locations were Kumarkhali, Kushtia; Rajendrapur, Sadar, Netrakona; Challisha, Sadar, Netrakona; Laksam, Comilla; Purbadhala, Netrakona; Burichang, Comilla; Richi, Sadar, Habiganj; Sadar, Rangpur; Mithapukur, Rangpur; Gopalpur, Godagari, Rajshahi and Paba, Rajshahi

d. Field trials of rice transplanter during Aman/2012

Same as Boro/2012 except following

- Varieties : BRRI dhan49, BRRI dhan33 and BINA dhan7
- Seedling age : 18-22 for machine transplanting and 35 days for hand transplanting

Season: Aman/2012

Location/site

Total number of 11 field trails was conducted in different location to observe the field performance of the mechanical rice transplanter. The locations were Laksam , Comilla; Burichang, Comilla; Nakla, Shrer

pur; Sadar, Kushtia; Kumarkhali, Kushtia; Purbadhala, Netrakona; Sadar, Netrakona; Sadar, Rangpur; Mithapukur, Rangpur; Sadar, Habiganj and BRRI, Gazipur.

Table 8. General information of the Rice Transplanter trials, Aman/2012

Place	Variety	Area (decimal)	Date of seedling	Date of transplanting	Date of harvesting
Laksam , Comilla	BRRI dhan49	33	02/07/12	19/7/12	13/11/12
Burichang, Comilla	BRRI dhan49	35	05/07/12	20/7/12	13/11/12
Nakla, Shrerpur	BRRI dhan49	29	05/07/12	28/7/12	15/11/12
Sadar, Kushtia	BRRI dhan49	26	05/07/12	30/7/12	15/11/12
Kumarkhali, Kushtia	BINAI dhan7	39	12/07/12	31/7/12	11/11/12
Purbadhala, Netrakona	BRRI dhan49	32	12/7/12	03/08/12	22/11/12
Sadar, Netrakona	BRRI dhan33	41	12/7/12	04/08/12	10/11/12
Sadar, Rangpur	BRRI dhan49	33	15/7/12	07/08/12	24/11/12
Mithapukur, Rangpur	BRRI dhan49	37	18/7/12	08/08/12	24/11/12
Sadar, Habiganj	BRRI dhan49	26	18/7/12	09/08/12	25/11/12
BRRI, Gazipur	BRRI dhan49	33	18/7/12	10/08/12	25/11/12

e. Performance evaluation of rice transplanter in un-puddle condition

The experiment was conducted in Laksam and Burichong Upazila of Comilla district and Kumarkhali Upazila of Kushtria district during Aman 2012 season representing the sandy loam, clay loam and clay soil condition respectively with the following treatments.

Treatments

T_1: Conventional tillage (Transplanting in puddle condition)

T_2: Zéro tillage (Transplanting in un-puddle condition)

RCBD design was used with three replications. Seedling was raised in both plastic tray and polythene sheet. Walk behind type 4 rows mechanical rice transplanter was used to conduct the study. BRRI dhan49 was transplanted in Laksam and Burichong, Comilla and BINA dhan7 was in Kumarkhali, Kushtia. 20 days old seedling was transplanted with the spacing of 30×15 cm.

Season: Aman/2012

Experimental characteristics

BRRI recommended fertilizer dose was applied for BRRI dhan49 and BINA dhan7 to conduct the study. Triple super phosphate (TSP), muriate of potash (MoP), zinc sulphate (ZnSo4) and Gypsum fertilizer was used as basal dress fertilizer. Urea fertilizer was used as top dress in three different times as follows. The rate of basal dose and top dress of fertilizer is given in Table 9. General information of the experiment is also presented in the Table 9.

Table 9. General information of the un-puddled experiment, Aman/2012

Place	Variety	Plot size (ha)		Fertilizer rate (kg/ha)					D/T	Date of harvesting
		Puddle	Un-puddle	TSP	MOP	Gyp	$Znso_4$	Urea		
Kumarkhali Kushtia	BINA dhan7	0.185	0.122	105	75	75	7.5	180	31/7/12	11/11/12
Laksam Comilla	BRRI dhan49	0.137	0.08	80	80	80	7.5	185	20/7/12	13/11/12
Burichong Comilla	BRRI dhan49	0.134	0.102	100	90	80	7.5	185	20/7/12	13/11/12

Transplanter setting during operation

There have three options in the walk behind type mechanical rice transplanter to adjust plant to plant spacing. 15 cm plant to plant spacing was adjusted during transplanting. There have also three options for depth of seedling placing. In the puddle field, transplanting depth control lever was set at slight mode where as it was set at deep mode in un-puddle field. Number of seedlings/hill was adjusted considering seedling density for maintaining same number of plants/hill. There have nine options to select number of seedling per hills. During transplanting, option 5 was adjusted for transplanting.

Soil resistance

Hand Penetrometer Eijkelkamp was used to measure the soil penetration resistance (Model: Ejkelkemo, Serial no. 27180909, Netherlands) of the both puddle and un-puddle field before transplanting. Cone resistance was calculated using the following formula:

$$\text{Cone resistance} = \frac{\text{Manometer reading}}{\text{Base area of cone}}, \text{N/cm}^2 \quad (100 \text{ N/cm}^2 = 1 \text{ Mpa})$$

3 and 4 nos cone were used to measure the soil resistance. Base area of cone 1, 2, 3 and 4 is 1, 2, 3.33 and 5 cm^2 respectively. Soil strength was measured from the soil surface to a depth of 22 cm. Penetrometer readings were taken randomly in three places of the each plots.

Yield and yield contributing data collection

10 m^2 area was selected randomly from each plot to collect yield and yield contributing data. Yield data was collected from 10 m^2 area and adjusted to 14% moisture content. Straw yield, number of tillers/hill and number of panicles/hill was counted from 1 m^2 area outside of 10 m^2 pre-selected areas. Number of hills/m^2 was counted from total number of hills in 10 m^2 pre-selected area. Plant height, panicle length, number of filled grains/panicle, number of un-filled grains/panicle, 1000 grains weight were counted from three hills randomly taken from each 1 m^2 area. The straw of three hills also added with straw of 1 m^2 area for straw yield calculation.

f. Field trials of rice transplanter during Boro/2013

Same as Boro/2012 season except following

- Varieties : BRRI dhan29, BRRI dhan28 and BRRI dhan50
- Seedling age : 22 to 28 for machine transplanting and 40 days for hand transplanting
- Spacing: 30 ×15 cm for machine and 20 x 15 cm for hand.

Season: Boro/2013

Location/site

Total number of 21 field trails was conducted in different location to observe the field performance of the mechanical rice transplanter. The locations were Jatrapasha, Habiganj; Hislakor Purbapara, Kumarkhali; Hislakor Pashim para, Kumarkhali; Hislakor Dakkin para, Kumarkhali; Hislakor Primary school area, Kumarkhali; Sutrapur, Rangpur; Gohalakanda, Purbadhala; Mohismara, Burichang, Comilla-1; Gazipur, Burichang,

Comilla-1; Ratanpur, Sadar, Habiganj; Sutrapur, Rangpur; Challisha, Sadar, Netrakona; Paba, Rajshahi-1; Paba, Rajshahi-2; Battail, Sadar, Kushtia; Purbadhala, Netrakona; Shripur, Laksam, Comilla; Gazipur, Burichang, Comilla-2; Baniachang, Habiganj; Joyrampur, Mithapukur, Rangpur-1 and Joyrampur, Mithapukur, Rangpur-2.

Table 10. General information of the Rice Transplanter field trials during Boro/2013

Place	Variety	Area (decimal)	Date of seedling	Date of transplanting	Date of harvesting
Jatrapasha Habiganj	BRRI dhan28	33	25/12/2012	02/02/2013	17/05/2013
Hislakor-1 Kumarkhali	BRRI dhan29	35	20/12/2012	17/01/2013	29/05/2013
Hislakor-2 Kumarkhali	BRRI dhan29	29	20/12/2012	17/01/2013	29/05/2013
Hislakor-3 Kumarkhali	BRRI dhan29	26	20/12/2012	18/01/2013	30/05/2013
Hislakor-4 Kumarkhali	BRRI dhan29	39	20/12/2012	18/01/2013	30/05/2013
Sutrapur Rangpur	BRRI dhan28	32	23/1/2013	16/02/2013	14/06/2013
Gohalakanda Purbadhala	BRRI dhan28	41	01/01/2013	28/02/2013	19/05/2013
Mohismara Burichang-1 Comilla	BRRI dhan28	33	08/01/2013	02/02/2013	27/05/2013
Burichang-2 Comilla	BRRI dhan28	37	12/01/2013	02/02/2013	31/05/2013
Sadar Habiganj	BRRI dhan28	26	01/01/2013	01/02/2013	20/05/2013
Sutrapur Rangpur	BRRI dhan28	33	06/01/2013	08/02/2013	26/05/2013
Sadar Netrakona	BRRI dhan29	40	11/01/2013	11/02/2013	23/06/2013
Paba-1 Rajshahi	BRRI dhan50	35	04/01/2013	14/02/2013	09/06/2013
Paba-2 Rajshahi	BRRI dhan50	38	04/01/2013	14/02/2013	09/06/2013
Sadar Kushtia	BRRI dhan28	27	02/02/2013	28/02/2013	22/06/2013
Purbadhala Netrakona	BRRI dhan29	29	03/01/2013	03/02/2013	14/06/2013
Laksam Comilla	BRRI dhan28	38	09/01/2013	06/02/2013	28/05/2013
Burichang-3 Comilla	BRRI dhan28	36	10/01/2013	09/02/2013	01/06/2013
Baniachang Habiganj	BRRI dhan29	33	19/11/2012	19/12/2012	29/04/2013
Mithapukur-1 Rangpur	BRRI dhan28	38	06/01/2013	01/02/2013	25/05/2013
Mithapukur-2 Rangpur	BRRI dhan28	27	19/01/2013	15/02/2013	20/05/2013

g. Modification of riding type rice transplanter for un-puddled transplanting

Korean made riding type mechanical rice transplanter collected under NATP funded sub-project. An initiative was taken to modify the rice transplanter for un-puddle transplanting. As a part of development, strip tillage mechanism was attached before the transplanting picker. MS sheet, flat bar, angle bar, shaft bar, sprocket, pulley, bevel gear, tine, chain etc. was used as fabricating materials. Design the strip tillage mechanism and power transmission system using AutoCAD Program. Major specifications of the riding type transplanter are as follows.

Table 11. Specification of Seating/Riding Type Rice Transplanter

Country of Origin			South Korea
Model			S3-680
Type			Ride on Type
Dimensions	Overall length (mm)		3120
	Overall width (mm)		2140
	Overall height (mm)		1655
	Overall weight (kg)		620
	Type		4-stock, air-cooled OHV gasoline
	Displacement (CC)		437
	Maximum output (kW/rpm)		10.5/3600
	Fuel tank capacity (L)		15 - 20
	Starting method		Electric motor start mode
Traveling Section	Steering		Hydraulic power steering mode
	Tires	Front	Anti-puncture tire
		Diameter (mm)	650
		Rear	Solid rubber
		Diameter (mm)	900
	Gearshift	Forward	2 speeds (Stepless variable speed)
		Reverse	1 speed
Transplanting Section	Transplanting mechanism		Rotary type
	Number of rows		6
	Transplanting distance (cm) (row to row)		30
	Transplanting distance (cm) (plant to plant)		14,16, 18, 20
	Planting pitch control		Adjustable
	Planting depth control		Adjustable
	Planting depth (cm)		0.8 – 4.4
	Number of spare seedling rack		6
	Transplanting speed (m/sec)		0 to 1.36

Power transmission mechanism

Existing power tiller was used as prime mover of the rice transplanter. Engineering design was done based on rice transplanter specification to attach the strip tillage mechanism before the rotary/transplanting picker.

RPM of the strip tillage rotary was calculated based on the following equations:

RPM of the 1st shaft, $R_2 = D_1 R_1 / D_2$ ..... (1)

Where, D_1 = Diameter of the rice transplanter engine pulley

D_2 = Diameter of the shaft pulley

R_1 = RPM of the rice transplanter engine pulley

RPM of the 2nd shaft, $SR_2 = SR_1 \times ST_1 / ST_2$ .....(2)

Where, SR_1= RPM of the sprocket of 1st shaft (Power transmission shaft)

ST_1 = Number of teeth of the sprocket of 1st shaft

ST_2 = Number of teeth of the sprocket of the 2nd shaft

RPM of the 3nd shaft, $SR_3 = SR_2 \times ST_2 / ST_3$

Where, SR_2= RPM of the sprocket of 2nd shaft (Power transmission shaft)

ST_2 = Number of teeth of the sprocket of 2nd shaft

ST_3 = Number of teeth of the sprocket of the 3rd shaft…….(3)

RPM of the strip tillage shaft, $SR_4 = SR_3 \times ST_3 / ST_4$

Where, SR_3= RPM of the sprocket of 3rd shaft (Power transmission shaft)

ST_3 = Number of teeth of the sprocket of 3rd shaft

ST_4 = Number of teeth of the sprocket of the strip tillage/4th shaft…….(4)

Location/Site

FMPHT divisional research workshop

Stages of power transmission

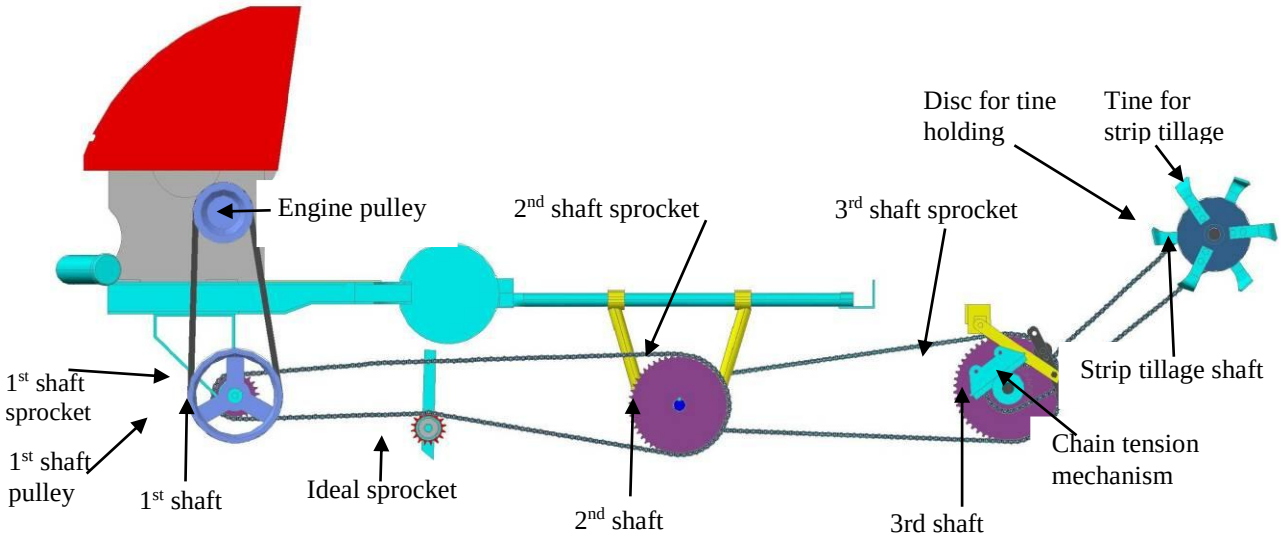


Fig. 21. Power transmission arrangement for strip tillage (side view)

Design considerations

- Strip tillage mechanism should be simple to make strip in the field.
- Depth of strip should not more than 2.5-5.0 cm
- Power transmission system should be simple with on off facility
- Locally available materials should be used to minimize the fabrication cost.
- During operation, it should be trouble free.

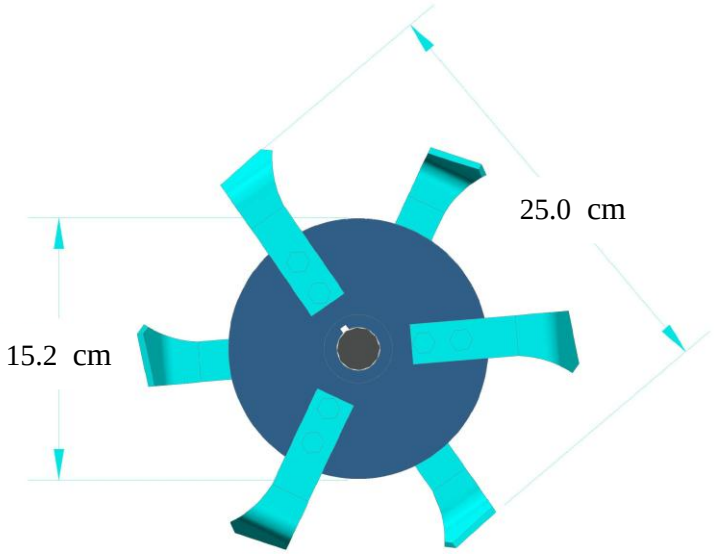


Fig. 22. Tine arrangement for strip tillage

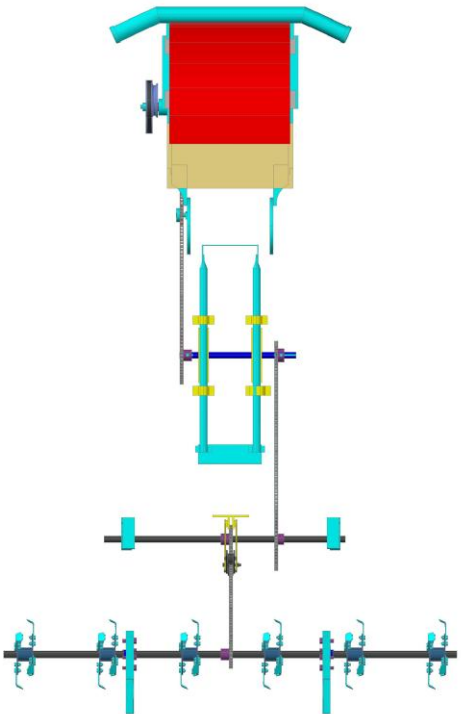


Fig. 23. Power transmission arrangement for strip tillage (top view)

Specifications of the different components of strip tillage mechanism

Engine power was transmitted in strip tillage shaft by reduction RPM in three stages. Name and specifications of the different components are given in Table 12.

Table 12. Specification of different components of strip tillage arrangement

Name	Specifications	Name	Specifications
Engine pulley	12.75 cm dia	Ideal sprocket	16 teeth
1st shaft pulley	20.35 cm dia	2nd shaft sprocket-1	50 teeth
1st shaft sprocket	23 teeth	2nd shaft sprocket-2	23 teeth
3dr shaft sprocket-1	50 teeth	Strip tillage sprocket	23 teeth
3dr shaft sprocket-2	23 teeth	Tine holding disc	

Different components of drawing are shown in Appendix-M.

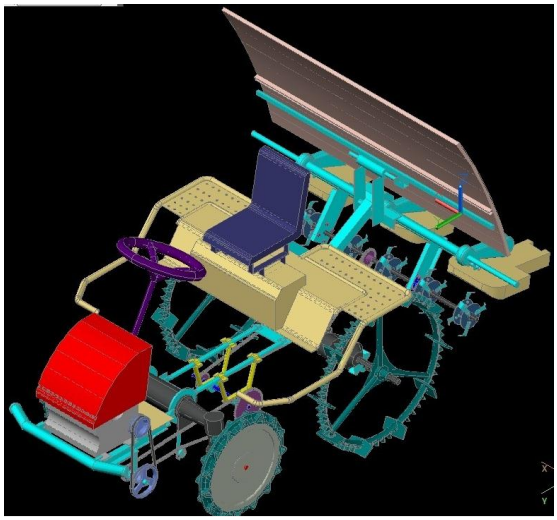


Fig. 24. Complete view of the riding type rice transplanter drawing (Isometric view)

h. Development of seedling raising technique for mechanical rice transplanter

The quality of seedling is very important for successful operation of mechanical rice transplanter. The seedling may be raised in a number of ways for machine transplanting i.e. dry and soft bed on polythene sheet, flexible and rigid tray and industrialized method. The seedling raised on polythene sheet is cut into slices of 28 × 58 cm size to feed into the seedling trays of the transplanter. However, the seedling raised in the tray can go directly to the transplanter tray because seedling tray and the transplanter tray are of same size.

Dry and soft bed on polythene sheet

A piece of perforated polythene sheet (The holes are made of 0.2 - 0.3cm diameter with 2 × 2 cm spacing) was placed on a leveled dry/wet bed and wood strips of 2.0-3.0cm wide and 2.0cm thick are used to control the thickness of seedbed and separate seedling block according to transplanter tray size (Fig. 25).

Flexible and rigid tray

Plastic tray of 28 × 58 × 2.5cm size was used for raising seedling. About 375 seedling trays are needed for one hectare land transplanting (Fig. 26). A total of fourteen treatments combing with different seed covering materials and dry and sprouted seed were used for this experiment. The cow-dung mixed soil and without cow-dung mixed soil were also used as treatment for this experiment.

Season: Boro/2010

Fig.25. Seedling raised on plastic tray

Fig.26. Seedling raised on polythene sheet

The treatments were as follows:

T1= Dry seed+ Soil+ Rice Husk
T2= Dry seed+ Soil+ Sawdust
T3= Dry seed+ Soil+ Soil
T4=Dry seed+ (Soil+ cow dung) + Rice Husk
T5= Dry seed+ (Soil+ cow dung) + Sawdust
T6= Dry seed+ (Soil+ cow dung) + Soil
T7=Sprouted+ Soil + Rice Husk
T8=Sprouted+ Soil + Sawdust
T9=Sprouted+ Soil + Soil
T10= Sprouted + (Soil+ cow dung) + Rice Husk
T11= Sprouted + (Soil+ cow dung) + Sawdust
T12= Sprouted + (Soil+ cow dung) + Soil
T13=Frame+ sprouted+ soil
T14=Frame+ dry seed+ soil

The pre-germinated seeds can't emerge quickly until they pass a period of high temperature and high humidity situation. So measures should be taken to increase temperature and humidity. Rice husk, sawdust, soil were used as seed covering materials to increase temperature and relative humidity surrounding the sowing seeds for this experiment. The sandy loam soil was collected for preparation of seedbed. To ensure soil free from clod, crop residues and weeds grinded the soil properly. At first clod free sandy loam soil mixed with organic fertilized, filled up the tray at a thickness of 2.0cm and spread 150g pre-germinated/dry seed in each tray according to the treatments. The amount of seed per tray depends on the 1000 grain weight of the recommended seed. In general, 120-150g pre-germinated seeds of normal varieties (inbreed) and 80-100g seeds of hydride rice are sowed per tray. When the radicals and coleoptiles elongate to 1/3 of seed length is desired for pre-germinated seed to broadcast on the tray. To ensure uniform broadcasting, the whole seed lot for each tray divided into 2-3 parts and then is broadcasted 2-3 times. After sowing, seedbed soil/sawdust/rice husk spread over the trays to 0.3-0.5cm thick and therefore the trays were kept under a shade to avoid birds attacked. After covering seeds, the two trays were placed side by side along each bed, make the bottoms of trays be in contact closely with the surface of the beds and irrigated the seedbed to an extent that the level of water just reaches the bottom of the trays and drain water after the soil get saturated. To drain excess water, canals are provided among the beds.

i. Development of seedling raising technique for mechanical rice transplanter

Same as methodology of *h.*

Season: Boro/2012

III. Training

A total of 11 Training program on "Seedling raising techniques for mechanical rice transplanter and operation & maintenance of farm machinery" during Aman/2011 (07 nos) and Aus/2012 (02 nos) at the locations of Kumarkhali, Kushtia (01); Sadar, Netrakona (01); Purbadhala, Netrakona (01); Burichang, Comilla (01); Sadar, Rangpur (01); Paba, Rajshahi (01); Godhagari, Rajshahi (01); Mithapukur, Rangpur (01); Sadar, Habiganj (02); Laksam, Comilla (01). Different categories of farmers, manufacturer and traders were participated in the training as trainee. Department of Agricultural Extension (DAE) personnel were involved closely to select participants, farmers and other logistic. Participants awarded about seedling raising techniques and operation of rice transplanter and USG Applicator. Seedling preparation, soil collection and preparation, tray preparation, seed sowing and covering, irrigation and other relevant activities was done by the participants.

Table 13. Brief information of the training on seedling raising techniques

Sl. no.	Date	Season	Number of participants	Type of participants	Place	Respective farmer	Respective scientist
1	27/07/2011	Aman/11	20 nos (male)	Different categories of farmers, school teacher, local elite and manufacturers.	Hatinakandha Block: Gohalakandha Union:11 nos Gohalakhanda, Purbadhala upazila, Netrakona.	Md. Jainal Abedin C/o: Late Siraj Uddin Cell: 01716-816392	Md. Anwar Hossen
2	28/07/2011	Aman/11	20 nos (male)	Different categories of farmers, school teacher and local elite	Rajendrapur Block: Challisha Union: Challisha Sadar Upazila, Netrakona.	Md. Badsha Miah C/o: Late Nawab Ali	Md. Anwar Hossen
3	30/07/2011	Aman/11	20 nos (male)	Different categories of farmers, school teacher, local leader and local elite	Mahizmara Block: Kharataiya Union: Kharataiya, Burichong Upazila, Comilla.	Md. Nurul Islam Member C/o: Late Yakub Ali	Md. Anwar Hossen
4	31/07/2011	Aman/11	20 nos (male)	Different categories of farmers, school teacher, local leader and	Venue: R/S Rangpur Farmers from: Kabirajpara, Dharmadas, Sadar, Ragpur	Md. Abdur Razzak	Dr. Md. Durrul Huda

Sl. no.	Date	Season	Number of participants	Type of participants	Place	Respective farmer	Respective scientist
				local elite			
5	01/08/2011	Aman/11	20 nos (male)	Different categories of farmers, school teacher, local leader and local elite	Dari Batikamara Block: Batikamara Union: Batikamara, Kumarkhali Upazila, Kushatia	Md. Nurul Islam Member C/o: Late Yakub Ali	Md. Anwar Hossen
6	02/08/2011	Aman/11	20 nos (male)	Different categories of farmers, school teacher, local leader and local elite	Nrapati block, Laksham purba union, Laksham Upazila, Comilla	Md. Shahidulla C/o: Late Guna Gazi	Md. Anwar Hossen
7	02/08/2011	Aman/11	20 nos (male)	Different categories of farmers, school teacher, local leader and local elite	Venue: R/S Rajshahi Farmers from: Usufpur, Charghat, Rajshahi.	Md. Golam Nabi C/o: Md. Khalilur Rahman, Nutun Kasba, Paba	Dr. Md. Durrul Huda
8	03/08/2011	Aman/11	20 nos (male)	Different categories of farmers, school teacher, local leader and local elite	Venue: Godhagari, Rajshahi Farmers from: Gopalpur, Godhagari, Rajshahi.	Md. Abul Kashem, C/o: Late Wastur Ali, Gopalpur, Godhagari, Rajshahi.	Dr. Md. Durrul Huda
9	21/05/2012	Aus/12	20 nos (male)	Different categories of farmers, school teacher, local leader and local elite	Suraboi, Olipur block, Sadar, Habiganj	Md. Tajul Islam C/o: Abdur Sattar	Md. Anwar Hossen
10	22/05/2012	Aus/12	20 nos (male)	SAAO from different blocks of Lassam, Comilla	Duria, Bisnapur, Laksam, Comilla	Md. Rukun Uddin C/o: Md. Hafizur Rahaman	Md. Anwar Hossen
11	23/05/2012	Aus/12	20 nos (male)	Different categories of farmers, school teacher, local leader and local elite	Suraboi, Olipur block, Sadar, Habiganj	Md. Abdul Hamid C/o: Md. Motali Hossain	Md. Anwar Hossen

IV. Large scale validation trials of USG applicator and rice transplanter

Ten applicators were provided in each project location to the farmers with the help of DAE. Farmers were used these applicator under the guidance of DAE. Under large scale validation program, farmers used this applicator by themselves. DAE personnel only collected information about variety, date of transplanting, date of USG application and area of USG application. DAE and project personnel also provided knowledge to the farmers how to operate machine in the field. Mechanical rice transplanters were also operated in the project location under large scale validation program. Under this activity, seedling was raised in the farmers' field on polythene sheet. Name farmers, place, variety, date of transplanting, date of USG application and area covered are shown in Appendix O and P.

Season: Boro/2013

10. Results and discussion

I. USG applicator

a. Design and Development of a manually operated USG applicator

Fabrication of the applicator

As per design of the applicator, it was fabricated in the FMPHT research workshop by senior mechanics and technicians. The complete view of the fabricated applicator is shown in Fig. 27.

Fig. 27. Complete view of the fabricated applicator

Lab test result

USG/UMG dispensing efficiency

USG/UMG dispensing efficiency was measured in laboratory. During test, applicator was setup at upper position in such way that the drive wheel moves easily. Two third portion of the tank was filled with granule. The drive wheel was rotated for 20 times continuously at normal speed and then the dispensed granules were collected from the bottom of the output channel. Dispensing efficiency was calculated by counting the number of dispensed granule. In laboratory test conditions, dispensing efficiency was found around 98 percent. Average dispensing efficiency was found around 98.8 percent during test. The result of the laboratory test is given in Table 14.

Table 14. Laboratory tests results of USG Applicator, 2010

No. of trial	Number of rotation	Number of UMG dispense	% of dispense
1	20	98	98
2	20	99	99
3	20	97	97
4	20	97	97
5	20	99	99
6	20	100	100
		Average	98.33

Capacity of the applicator

Design capacity

Capacity of the applicator depends on the walking speed, land condition, soil type, operator strength and skill, uniformity of the granule, bonding freeness and strength of the granule. Design capacity of the applicator was calculated during laboratory test considering the different walking speed. Considering 2, 1.75 and 1.5 km/h operating speed, design capacity was found 39.52, 34.55 and 29.64 decimal per hour respectively.

Field test results

Field capacity (In fallow land)

Field capacity of the applicator was measured in the BRRI research field trial basis in the fallow land during 2009 by three different labors.

Time was recorded including losses and total distance passed. During test, average capacity was found 32 decimal/h (Table 15).

Table 15. Field operation in fallow land of USG Applicator, 2010

Diff. trial	Total time (min)	Distance passed (m)	Speed (km/hr)	Capacity (decimal/hr)
1	10	260	1.56	30.82
2	13	351	1.62	32.01
3	9	251	1.67	32.99

N.B: Constant effective width=0.8m

Gap between dispensed granules

Distance between granules was considered 40 cm during design. It might be varied in the field during operation due to more penetration of the drive wheel. Because of more penetration, periphery of the wheel was reduced. As a result distance between granules is also reduced. Distance between granules was found 39.5 cm in the field (Table 16).

Table 16. Distance between dispensed granules during field trails, 2010

Trials	Number of reading	Highest length (cm)	Lowest length (cm)	Average length (cm)
1	4	40	38	39.75
2	4	40	39	39.5
3	4	42	39	39.75
4	4	40	37	39.0
Average				39.5

Depth of granule placement

It is important to place the granule at desired depth for efficient use of nitrogen uptake. The depth of placement is varied with soil condition and penetration of the applicator during operation. Different depth of granules placement was found during operation (Table 17). Average depth of granules placement was found 6.63 cm.

Table 17. Depth of placement of USG granules during field operation, 2010

No. of trials	Number of reading	Highest depth (cm)	Lowest depth (cm)	Average depth (cm)	Remarks
1	4	8	5	6.5	Because of different penetration of the skid, depth of placement varied
2	4	7	6	6.5	
3	4	8	6	7.25	
4	4	7	6	6.25	
Average				6.63	

b. Improvement of USG applicator

Laboratory test of the improved applicator

During test, applicator was setup at upper position in such a way that the drive wheel moves easily. Two third portion of the tank was filled with granule. The drive wheel was rotated for 20 times continuously at normal speed and then the dispensed granules were collected from the bottom of the output channel. Dispensing efficiency was calculated by counting the number of dispensed granule. In laboratory test conditions, dispensing efficiency was found around 99 percent. The result of the laboratory test is given in Table 18.

Table 18. Laboratory tests result of Improved applicator, 2012

No. of trial	Number of rotation	Number of UMG dispensed	% of dispensed UMG
1	20	102	100
2	20	100	100
3	20	97	97
4	20	98	98
5	20	99	99
6	20	100	100
Average			99

Field test of the improved applicator

Modified BRRI USG was operated in BBRI Gazipur research plot to observe the performance and compare with tradition placement method of USG. Field capacity of the modified version also compared with the previous version of BRRI USG Applicator.

Table 19. Field performance of the improved Applicator, 2012

Items	BRRI USG Applicator (adjustable type)	BRRI USG Applicator (fixed type)	Traditional application
Time of application[1](min)	43	41	133
Area covered (decimal)	25	25	10
Walking speed (km/hr)	1.95	1.85	-
Field capacity (decimal/hr)	32.5	31.80	4.5
Depth of of placement (cm)	5-6	5-6	4-5
Wt. of dispensed USG (Kg/ha)	165	168	165

[1] Time of operation is the total time including turning, USG filling, machine setting and other losses.

During field operation of the applicator average walking speed of the operator was found 1.95 km/hr for adjustable type applicator, 1.85 km/hr for fixed type applicator. Field capacity were about 32.5 decimal/hr and 31.80 decimal/hr for adjustable type and fixed type applicator respectively whereas manual USG application capacity was found 4.5 decimal/hr. Average depth of placement of the granule were 5-6 cm for applicator and 4-5 cm for manual placing (Table 19).

Table 20. Amount of dispanced granules for three different adjustment of the improved applicator

Season	Recommended size of granules (gm)	Amount of USG dispanced (kg)		
		Spacing 18 cm x 20 cm	Spacing 20 cm x 20 cm	Spacing 22 cm x 20 cm
Boro	2.7	187	168	153
Aman	1.8	125	112	102

Fertilizer dose was varied with different adjustment. Normally 168 kg urea for Boro and 112 kg urea for Aman season is recommended as USG form. There are possibilities of under and over dose of fertilizer for 18 and 22 cm adjustment respectively. Therefore it is recommended to use the applicator for standard 20 cm line to line spacing.

c. Research station based trials of USG applicator during Aman/2010

During field operation of the applicator average walking speed of the operator was found 3.72 km/hr and field capacity was about 35 decimal/hr whereas manual USG application capacity was found 4.5 decimal/hr. Average depth of placement of the granule was around 6.32 cm (Table 21). Photograph of field trials in different locations are presented in Apendix-B (Fig.B1 to Fig.B4). BRRI dhan49 was cultivated in all locations except netrakona where BRRI dhan33 was cultivated. 1.8 gm size granule was applied in the field to evaluate the applicator. The calculated dose of USG was about 118 kg/ha whereas prilled urea was 200 kg/ha. Others fertilizer dose was similar irrespective of all treatments. USG was applied at 10-12 days after transplanting.

Table 21. Field performance of the BRRI USG Applicator during Aman/2010

Places	Time of operation for USG application[1] (min)		Area covered (decimal)		Walking speed (km/hr)	Field capacity (ha/hr)		Depth of of place-ment (cm)		Wt. of dispensed USG[2] (Kg/ha)	
	App.	Hand	App.	Hand	App.	App.	Hand	App.	Hand	App.	Hand
BRRI, Gazipur	54	408	30	30	3.45	0.134	0.018	6.8	5.8	118.5	112.0
BRRI, Kushtia	31	162	20	10	3.95	0.157	0.015	6.0	5.4	119.5	115.5
BRRI, Rajshahi	35	116	20	10	3.55	0.139	0.021	6.0	5.9	118.0	110.0
BRRI, Rangpur	32	128	20	10	3.87	0.152	0.019	6.0	5.5	116.7	112.5
BRRI, Comilla	31	142	20	10	3.90	0.157	0.017	6.6	5.7	119.5	116.0
Netrakona	89	243	5o	20	3.60	0.136	0.020	6.5	6.2	120.0	114.0
Average					3.72	0.146	0.018	6.32	5.75	118.7	113.33

[1] Time of operation is the total time including turning, USG filling, machine setting and other losses.

There was no significant yield variation observed in different N fertilization method in studied six locations except kushtia (Table 22). In kushtia, yield was significantly higher when N was applied as USG applying by USG applicator than other treatments. In all the cases, USG gave higher yield than prilled urea. Although the performance of USG was applied by USG applicator of hand was not consistent.

Table 22. Yield performance of BRRI varieties in different locations as affected by different method of N fertilization

Treat	Yield (t/ha)						Average yield (t/ha)	
	BRRI R/S, Kushtia	BRRI R/S, Rajshahi	BRRI, Gazipur	Netrakona	BRRI R/S, Comilla	BRRI R/S, Rangpur	BRRI Dhan49	BRRI Dhan33
	BRRI Dhan49	BRRI Dhan49	BRRI Dhan49	BRRI Dhan33	BRRI Dhan49	BRRI Dhan49		
T_1	5.750a	4.96a	4.973a	4.85a	4.927a	5.05a	5.13	4.85
T_2	5.343ab	5.58a	4.633a	4.98a	4.657a	5.24a	5.09	4.98
T_3	4.803b	4.67a	4.450a	4.17a	4.510a	4.75a	4.64	4.17

In some locations, USG applying by USG applicator gave higher yield than hand application or vis-à-vis. Although there was no significant difference found in studied three treatments but USG gave around 0.5 t/ha more yield than prilled urea. It might be due to the USG produced higher effective tiller/m^2 as well as higher grains/m^2 resulted of higher yield (Table 23-28).

Table 23. Performance of yield and yield contributing parameters, BRRI R/S Kushtia

Treat.	No. of tiller/m^2 at			Avg. plants height (cm)	Avg. Panicle length (cm)	Grain/ panicle	No. of effective tiller/m^2	% of sterility	1000 grains weight at 14% m.c. (gm)	yield at 14% m.c. (t/ha)
	25 DAT	55 DAT	harvest							
T_1	318a	399a	366a	105.5a	20.93a	97a	293a	19.85a	20.35a	5.750a
T_2	278b	362ab	341a	103.5a	20.32a	95a	278a	16.55a	20.52a	5.343ab
T_3	232c	320b	308b	105.2a	21.43a	98a	248b	17.56a	20.05b	4.803b
% of CV	5.96	5.24	3.90	1.02	4.50	3.70	3.68	16.85	0.55	4.97
LSD value	37.26	42.74	29.91	2.42	2.13	8.10	22.74	6.87	0.25	0.59

Tiller number at 55 DAT and at harvest was found statistically similar in the both T_1 and T_2 applying USG by hand and machine respectively whereas it was found significantly less in T_3 applying prilled urea by broadcasting method at BRRI R/S kushtia. But plant height was found 105.5, 103.5 and 105.2 cm for three treatments respectively. Average panicle length was 20.93, 20.32 and 21.42 cm and grain/panicle was 97, 95 and 98 nos. for T_1, T_2 and T_3 respectively. But plant height, grain/panicle and % of sterility were found statistically identical in all treatments. Number of effective tiller/m^2 was 293, 278 and 248 and1000 gm was 20.35, 20.52 and 20.05 gm for T_1, T_2 and T_3 respectively. Number of effective tiller and 1000 g was statistically identical in the both T_1 and T_2 whereas it was significantly less in T_3. Yield (t/ha) was found 5.75, 5.34 and 4.80 for T_1, T_2 and T_3 respectively. Yield of T_2 was statistically similar with T_1 and T_3 was similar with T_2. Moreover yield in T_1 significantly more than T_3 (Table 23).

Table 24. Performance of yield and yield contributing parameters, BRRI R/S Rajshahi

Treat.	No. of tiller/m^2 at			Avg. plants height (cm)	Avg. Panicle length (cm)	Grain/ panicle	No. of effective tiller/m^2	% of sterility	1000 grains weight at 14% m.c. (gm)	yield at 14% m.c. (t/ha)
	25 DAT	55 DAT	harvest							
T_1	248a	387a	362a	103.0a	19.03a	96a	261a	10.13a	19.75a	4.96a
T_2	249a	400a	388a	103.3a	19.40a	96a	295a	12.97a	19.55a	5.58a
T_3	226a	346a	329a	101.9a	19.13a	99a	235a	12.63a	19.68a	4.67a
% of CV	7.54	8.33	7.11	1.02	4.55	9.27	9.95	29.30	1.83	15.73
LSD value	41.21	71.28	57.96	2.373	1.980	20.33	59.45	7.913	0.8174	1.808

Yield and yield contributing parameters for T_1, T_2 and T_3 was found statistically identical at BRRI R/S Rajshahi. Average panicle length was 19.03, 19.40 and 19.13cm and grain/panicle was 96, 96 and 99 for T_1, T_2 and T_3 respectively. Number of effective tiller/m^2 was 261, 295 and 235 and1000 grain weight was 19.75, 19.55 and 19.68 gm for T_1, T_2 and T_3 respectively. Yield (t/ha) was found 4.96, 5.58 and 4.67 for T_1 , T_2 and T_3 respectively (Table 24).

Table 25. Performance of yield and yield contributing parameters, BRRI Gazipur

Treat.	No. of tiller/m^2 at			Avg. plants height (cm)	Avg. Panicle length (cm)	Grain/ panicle	No. of effective tiller/m^2	% of sterility	1000 grains weight at 14% m.c. (gm)	Yield at 14% m.c. (t/ha)
	25 DAT	55 DAT	harvest							
T_1	256a	346a	334a	97.97a	20.13a	92a	285a	9.970a	19.20a	4.973a
T_2	260a	328a	311a	98.27a	20.70a	96a	254a	12.59a	19.14a	4.633a
T_3	241a	309a	296a	96.80a	20.30a	98a	245a	9.793a	18.80a	4.450a
% of CV	14.11	9.60	8.72	2.91	4.62	11.29	11.26	32.23	2.00	9.42
LSD value	80.65	71.31	61.99	6.442	2.134	24.40	66.70	7.879	0.8632	1.001

Yield and yield contributing parameters for T_1 , T_2 and T_3 was found statistically identical at BRRI Gazipur. Average panicle length was 20.13, 20.70 and 20.30 cm and grain/panicle was 92, 96 and 98 for T_1 , T_2 and T_3 respectively. Number of effective tiller/m^2 was 285, 254 and 245 and1000 grain weight was 19.20, 19.14 and 18.80 gm for T_1 , T_2 and T_3 respectively. Yield (t/ha) was found 4.97, 4.63 and 4.45 for T_1 , T_2 and T_3 respectively (Table 25).

Table 26. Performance of yield and yield contributing parameters, farmer's field at Netrakona

Treat.	No. of tiller/m^2 at			Avg. plants height (cm)	Avg. Panicle length (cm)	Grain/ panicle	No. of effective tiller/m^2	% of sterility	1000 grains weight at 14% m.c. (gm)	yield at 14% m.c. (t/ha)
	25 DAT	40 DAT	harvest							
T_1	220ab	291ab	279a	106.7a	23.07a	109a	230a	16.15b	19.26a	4.85a
T_2	231a	298a	283a	101.4a	23.37a	111a	232a	13.92c	19.42a	4.98a
T_3	212b	274b	274a	101.2a	21.83a	99b	217a	18.57a	19.31a	4.17a
% of CV	2.84	2.76	4.06	9.12	5.77	2.65	6.24	5.45	3.19	9.53
LSD Value	14.25	17.99	25.63	21.32	2.977	6.389	32.04	2.001	1.399	1.009

Tiller number at 25 DAT and 55 DAT was significantly higher in T_2 compare to T_3. Tiller number of T_2 and T_3 at 25 DAT and 55 DAT was statistically similar with T_1. Tiller number at harvest was found statistically identical in all treatments. Moreover plant height and panicle length was found identical for all treatments. Grain/panicle was 109, 111 and 99 for T_1 , T_2 and T_3 and both of T_1 and T_2 was significantly higher than T_3. Panicle/m^2 was 230, 232 and 217 for T_1 , T_2 and T_3 and all was statistically identical. Percent of sterility was found significantly more in T_3 compare to T_1 and T_2 whereas T_1 was more compare to T_2. 1000 grain weight was 19.26, 19.42 and 19.31 gm for T_1 , T_2 and T_3 respectively. 1000 grain weight was statistically identical for all treatments. Yield (t/ha) was found 4.85, 4.98 and 4.17 for T_1 , T_2 and T_3 respectively which was statistically identical (Table 26).

Table 27. Performance of yield and yield contributing parameters, BRRI R/S Comilla

Treat.	No. of tiller/m^2 at			Avg. plants height (cm)	Avg. Panicle length (cm)	Grain/ panicle	No. of effective tiller/m^2	% of sterility	1000 grains weight at 14% m.c. (gm)	yield at 14% m.c. (t/ha)
	25 DAT	55 DAT	harvest							
T_1	250a	349a	322a	99.63a	21.17a	88a	299a	14.67a	19.33a	4.927a
T_2	244a	352a	320a	100.1a	20.40a	86ab	297a	13.33a	19.03a	4.657a
T_3	238a	343a	317a	95.54a	20.13a	82b	297a	16.00a	19.32a	4.510a
% of CV	2.90	4.02	1.57	2.37	3.16	2.98	2.41	7.87	1.35	5.48
LSD Value	16.06	31.75	11.40	5.290	1.473	5.755	16.29	2.617	0.5912	0.5824

Yield and yield contributing parameters for T_1 , T_2 and T_3 was found statistically identical at BRRI R/S Comilla except grain/panicle. Average panicle length was 21.17, 20.40 and 20.13 cm and grain/panicle was 88, 86 and 42 for T_1 , T_2 and T_3 respectively. Grain/panicle was significantly more in T_1 compare to T_3 and statistically similar with T_2 whereas T_3 also statistically similar with T_2. Number of effective tiller/m^2 was 299, 297 and 297 and1000 grain weight was 19.33, 19.03 and 19.32 gm for T_1, T_2 and T_3 respectively which was statistically identical in all treatments. Yield (t/ha) was found 4.927, 4.657 and 4.510 for T_1 , T_2 and T_3 respectively (Table 27).

Table 28. Performance of yield and yield contributing parameters, BRRI R/S Rangpur

Treat.	No. of tiller/m^2 at			Avg. plants height (cm)	Avg. Panicle length (cm)	Grain/ panicle	No. of effective tiller/m^2	% of sterility	1000 grains weight at 14% m.c. (gm)	yield at 14% m.c. (t/ha)
	25 DAT	55 DAT	harvest							
T_1	244a	313a	303a	87.73a	20.17a	96a	273a	14.61a	19.50a	5.05a
T_2	257a	308a	290a	82.60a	18.63b	97a	286a	16.02a	19.34a	5.24a
T_3	242a	293a	286a	84.27a	9.67ab	106a	244a	3.33a	18.77b	4.75a
% CV	2.97	3.24	3.80	5.96	2.89	7.01	8.31	10.87	0.91	7.60
LSD Value	16.70	22.34	25.21	11.47	1.278	15.81	50.43	3.610	0.3991	0.8632

Yield and yield contributing parameters for T_1 , T_2 and T_3 was found statistically identical at BRRI Rangpur. Average panicle length was 20.17, 18.63 and 19.67 cm and grain/panicle was 96, 97 and 106 for T_1 , T_2 and T_3 respectively. Number of effective tiller/m^2 was 273, 286 and 244 and1000 grain weight was 19.50, 19.34 and 18.77 gm for T_1, T_2 and T_3 respectively. Yield (t/ha) was found 5.05, 5.24 and 4.75 for T_1, T_2 and T_3 respectively (Table 28).

d. Field trials of USG applicator in different locations during Boro/2011

BRRI USG was operated in different 12 locations of the country to evaluate the field performance of the applicator. During field operation of the applicator average walking speed of the operator was found 2.46 km/hr and average field capacity was 32.97 decimal/hr whereas manual USG application capacity was found 4.94 decimal/hr. Average depth of placement of the granule was around 6.01 cm (Table 29). Average 162 kg of USG fertilizer was dispensed per hector during applicator operation whereas 169.25 kg of USG fertilizer for hand application.

Table 29. Field performance of the BRRI USG Applicator operated in different places during Boro/2011

Places	Time of operation[1] (min)		Area (decimal)		Walking speed (km/hr)	Field capacity (ha/hr)		Depth of of place-ment (cm)		Wt. of dispensed USG (Kg/ha)	
	App.	Hand	App.	Hand	App.	App.	Hand	App.	Hand	App.	Hand
Sadar Kushtia	65	418	35	35	2.4	0.13	0.02	6.0	5.5	165.0	169.0
Tarapur Kumarkhali	62	265	30	20	2.2	0.12	0.02	5.9	5.2	169.0	172.0
Sadar Habiganj	47	114	25	10	2.8	0.13	0.02	5.8	5.8	162.0	169.0
Baniacang Habiganj	48	53	25	5	2.8	0.13	0.02	6.0	5.8	158.0	165.0
BRRI R/S Habiganj	26	51	16	4	2.2	0.15	0.02	6.2	6.0	162.0	167.0
Burhicang Comilla	50	42	25	5	2.5	0.12	0.03	6.0	5.5	160.0	169.0
Narpati Laksam	51	49	25	5	2.2	0.12	0.02	6.2	5.6	162.0	169.0

Places	Time of operation[1] (min)		Area (decimal)		Walking speed (km/hr)	Field capacity (ha/hr)		Depth of of place-ment (cm)		Wt. of dispensed USG (Kg/ha)	
	App.	Hand	App.	Hand	App.	App.	Hand	App.	Hand	App.	Hand
Sutrapur Rangpur	49	50	25	5	2.7	0.12	0.02	5.8	5.4	152.0	171.0
Akkelpur, Rangpur	50	50	25	5	2.9	0.12	0.02	5.9	5.1	156.0	172.0
Sadar Netrakona	46	49	25	5	2.3	0.13	0.02	6.1	5.4	160.0	170.0
Purbadhala Netrakona	47	51	25	5	2.2	0.13	0.02	6.2	6.0	162.0	168.0
Paba Rajshahi	36	92	20	8	2.3	0.13	0.02	6.0	6.0	165.0	170.0
Average					2.46	0.13	0.02	6.01	5.61	162	169.25

[1] Time of operation is the total time including turning, USG filling, machine setting and other losses.

BRRI dhan29 was cultivated in all locations except Sutrapur, Sadar, Rangpur where BRRI dhan28 was cultivated. 2.7 gm size granule was applied in the field to evaluate the applicator. The calculated dose of USG was about 168 kg/ha whereas prilled urea was about 280 kg/ha. Others fertilizer dose was similar irrespective of all treatments. USG was applied at 10-12 days after transplanting. Date of seedling, transplanting, USG and prilled urea application is presented in Table 29. Photographic view of field operations and crop conditions are shown in Apendix-C (Fig. C1 & C2).

Table 30. Yield performance of BRRI varieties in different locations as affected by different method of N fertilization.

Treat.	Yield (t/ha)												Average yield (t/ha)	
	Sadar, Kushtia	Kumar., Kushtia	Sadar, Habiganj	Bania-cang	BRRI Habi-ganj	Burir-chang	Laksam	Sadar, Rangpur	Sadar, Rangpur	Sadar, Netra-kona	Purba-dhala	Paba Rajshahi	BRRI Dhan29	BRRI Dhan28
	BRRI Dhan29	BRRI Dhan29	BRRI Dhan29	BRRI Dhan29	BRRI Dhan29	BRRI Dhan29	BRRI Dhan29	BRRI Dhan28	BRRI Dhan29	BRRI Dhan29	BRRI Dhan29	BRRI Dhan29		
T_1	8.50a	9.96a	7.68b	7.97a	8.08a	8.25a	7.58a	6.7ab	6.83a	7.52a	7.33a	8.56a	8.02	6.71
T_2	8.62a	10.2a	7.94a	8.22a	8.28a	8.23a	7.71a	7.12a	6.55a	7.59a	7.47a	8.60a	8.13	7.12
T_3	8.03b	9.38b	6.82c	6.63b	8.11a	7.79a	6.44b	6.26b	6.20a	6.64b	6.64b	7.99b	7.33	6.26
% of cv	0.99	2.10	0.81	2.65	3.61	3.08	4.01	4.49	4.42	2.76	3.04	2.14	-	-
LS[1] (%)	*	**	*	*	ns	ns	**	ns	ns	*	**	**	-	-

[1]Level of significance

There were significant yield variation observed in different N fertilization method in studied locations except BRRI R/S, Habiganj; Burhicang, Comilla; Akkelpur, Rangpur. In kushtia (Sadar and Khumarkhali), Habiganj (Sadar and Baniacang), Laksam, Comilla; Sutrapur, Rangpur; Netrakona (Sadar and Purbadhala) and Paba, Rajshali, yield was significantly higher when N was applied as USG applying by both traditionally and USG applicator than prilled urea. In all the cases, USG gave higher yield than prilled urea. Although the performance of USG was applied by USG applicator and hand was not consistent.

In some locations, USG applying by hand gave higher yield than USG applying by USG Applicator or vis-à-vis. Considering the average yield of 12 locations; USG gave around 0.75 t/ha more yield than prilled urea. It might be due to the USG produced higher effective tiller/m^2 as well as higher grains/m^2 resulted of higher yield.

e. Field trials of USG applicator in different locations during Boro/2012

BRRI USG was operated at 10 different locations of the country to evaluate the field performance of the applicator. During field operation of the applicator average walking speed of the operator was found 1.93 km/hr and field capacity was about 0.15 ha/hr whereas manual USG application capacity was found 0.019 ha/hr. Average depth of placement of the granule was around 7.01 cm (Table 31).

BRRI dhan29 and BRRI dhan28 was cultivated in all locations. 2.7 gm size granule was applied in the field to evaluate the applicator. The calculated dose of USG was about 168 kg/ha whereas prilled urea was 270 kg/ha for BRRI dhan29 and 250 kg/ha for BRRI dhan28. Others fertilizer dose was similar irrespective of all treatments. USG was applied at 5-7 days after transplanting. Date of seedling, transplanting, USG and prilled urea application is presented in Table 32. Photographic view of field operations is shown in Apendix-D.

Table 31. Field performance of the BRRI USG Applicator operated in different places during Boro/12

Places	Time of operation[1] (min)		Area (decimal)		Walking speed (km/hr)	Field capacity (ha/hr)		Depth of of placement (cm)		Wt. of dispensed USG (Kg/ha)	
	App.	Hand	App.	Hand	App.	App.	Hand	App.	Hand	App.	Hand
Kumarkhali Kushtia	31	142	20	12	2.06	0.16	0.022	6.6	5.7	167.5	169.0
Sadar Netrakona	89	243	5o	20	1.75	0.14	0.019	6.5	6.2	164.0	169.0
Laksam Comilla	54	408	30	30	1.77	0.14	0.019	6.8	5.8	164.0	168.7
Purbadhala Netrakona	32	128	20	10	2.09	0.17	0.023	6.0	5.5	168.0	167.5
Burichang Comilla	31	142	20	10	1.96	0.16	0.019	6.6	5.7	167.0	168.0
Sadar Habiganj	89	243	5o	20	2.11	0.17	0.019	6.5	6.2	169.0	172.0
Sadar Rangpur	54	408	30	30	1.79	0.14	0.018	6.8	5.8	162.8	167.0
Paba Rajshahi	31	162	20	10	2.06	0.16	0.018	6.0	5.4	164.0	169.5
Godagari Rajshahi	35	116	20	10	1.73	0.14	0.023	6.0	5.9	161.0	170.0
Mithapukur Rangpur	31	162	20	10	1.96	0.16	0.014	6.0	5.4	165.0	171.0
Average					1.93	0.15	0.019	7.01	6.34	165.23	169.17

[1] Time of operation is the total time including turning, USG filling, machine setting and other losses.

Table 32. Yield performance of BRRI varieties in different locations as affected by different method of N fertilization

Treat.	Average yield (t/ha)										Average yield (t/ha)	
	Kumark., Kushtia	Sadar, Netrakona	Laksam, Comilla	Purba-dhala	Buri-chang	Sadar Habiganj	Sadar Rangpur	Paba Rajshahi	Goda-gari	Mitha-pukur	BRRI Dhan29	BRRI Dhan28
	BRRI Dhan29	BRRI Dhan29	BRRI Dhan28	BRRI Dhan29	BRRI Dhan29	BRRI Dhan29	BRRI Dhan29	BRRI Dhan29	BRRI Dhan28	BRRI Dhan29		
T_1	7.49	7.35	5.75	6.75	7.12	6.50	6.85	7.11	6.80	6.78	6.9	6.3
T_2	7.57	7.21	5.78	6.55	6.89	6.48	6.90	7.02	6.82	6.48	6.9	6.4
T_3	7.26	7.00	4.80	6.20	6.45	6.11	6.28	6.89	5.98	6.48	6.6	5.4

Yield variation was not observed in USG application by hand and applicator in studied ten locations (Table 32). In all the cases, USG gave higher yield than prilled urea. Although the performance of USG was applied by USG applicator or hand was not consistent. In some locations, USG applying by USG applicator gave higher yield than hand application or vis-à-vis. But USG gave around 0.6 t/ha more yield than prilled urea. It might be due to the USG produced higher effective tiller/m^2 as well as higher grains/m^2 resulted of higher yield.

f. Field trials of USG Applicator in different locations during Aman/2012

Yield variation was observed in 11 studied locations between mechanical and manual transplanting. In case of BRRI dhan49, average yield was found 4.48 and 4.29 t/ha in mechanical and manual transplanting plots respectively whereas 3.89 and 3.76 t/ha yield was observed in BRRI dhan33 respectively. BINA dhan7 also gave higher yield in the mechanical transplanting plots compared to manual transplanting which was 4.01 and 3.86 t/ha respectively. Mechanical transplanting gave around 0.17 t/ha more yields than manual transplanting. It might be due to produced higher effective tiller/m^2 as well as higher grains/m^2 resulted of higher yield (Table 34-36). Photographic view of field operations is shown in Apendix-5.

Table 33. Yield performance of BRRI varieties in different locations as affected by different method of transplanting

Treatment	Average yield (t/ha)		
	BRRI dhan49	BRRI dhan33	BINA dhan7
T_1	4.48	3.89	4.01
T_2	4.29	3.76	3.86

Table 34. Performance of yield and yield contributing parameters of BRRI dhan49 in different project locations

Place	Treat.	3-hills information						1000 grain wt. (gm)	Tiller /20m^2	Paddy wt. of 20 m^2 (kg)	M.C. (%)	Yield at 14% m.c. (t/ha)
		Plant height (cm)	No. of plants	No. of panicle	Panicle length (cm)	No. of grains /panicle	Sterile grains /panicle					
Laksam	T_1	101.4	39	28	21.5	108	32	20.65	435	9.35	19.50	4.38
Comilla	T_2	65.5	37	27	21.25	105	39	20.5	438	9.25	19.00	4.36
Burichang	T_1	102.5	41	30	21.45	106	29	20.78	435	10.30	21.00	4.73
Comilla	T_2	100	38	29	21	109	32	20.65	440	10.25	20.00	4.77

Place	Treat.	3-hills information						1000 grain wt. (gm)	Tiller /20m^2	Paddy wt. of 20 m^2 (kg)	M.C. (%)	Yield at 14% m.c. (t/ha)
		Plant height (cm)	No. of plants	No. of panicle	Panicle length (cm)	No. of grains /panicle	Sterile grains /panicle					
Nakla	T_1	102.75	40	27	21	111	37	20.42	436	10.00	19.50	4.68
Shrerpur	T_2	100.5	37	26	19.85	109	42	20.35	445	9.50	19.25	4.46
Sadar	T_1	101	37	29	21.75	102	35	20.5	430	9.25	21.35	4.23
Kushtia	T_2	100	36	27	21	106	32	20.45	430	8.75	21.25	4.01
Purbadhala	T_1	105.5	40	30	20.8	99	26	20.65	438	9.50	19.75	4.43
Netrakona	T_2	102.7	37	28	19.25	98	33	20.43	440	8.75	19.25	4.11
Sadar	T_1	101	36	32	22	98	29	21.2	445	10.25	19.35	4.81
Rangpur	T_2	112	33	29	22.35	99	21	21.15	440	9.65	19.15	4.54
Mithapukur	T_1	98.75	42	30	21.5	106	19	20.75	435	9.85	20.85	4.53
Rangpur	T_2	100.25	39	30	21	99	21	20.65	436	9.25	20.65	4.27
Sadar	T_1	103.45	37	29	21	94	20	21.03	450	9.02	21.28	4.13
Habiganj	T_2	103.25	32	26	20.75	92	29	21	455	8.45	21.12	3.88
BRRI	T_1	105	40	29	20.75	100	33	21.1	445	9.45	19.55	4.42
Gazipur	T_2	100.5	39	29	19.3	99	36	21	445	9	18	4.29

Table 35. Performance of yield and yield contributing parameters of BRRI dhan33 at Sadar, Netrakona

Place	Treat.	3-hills information						1000 grain wt. (gm)	Tiller /20m^2	Paddy wt. of 20 m^2 (kg)	M.C. (%)	Yield at 14% m.c. (t/ha)
		Plant height (cm)	No. of plant	No. of panicle	Panicle length (cm)	No. of grains /panicle	Sterile grains /panicle					
Sadar Netrakona	T_1	99.5	37	27	23.5	86	26	23.52	438	8.50	21.35	3.89
	T_2	65.7	32	26	22.45	83	27	23.48	440	8.20	21.22	3.76

Table 36. Performance of yield and yield contributing parameters of BINA dhan7 at Kumakhali, Kushtia

Place	Treat	3-hills information						1000 grain wt. (gm)	Tiller /20m^2	Paddy wt. of 20 m^2 (kg)	M.C. %	Yield at 14% m.c. (t/ha)
		Plant height (cm)	No. of plant	No. of panicle	Panicle length (cm)	No. of grains /panicle	Sterile grains /panicle					
Kumarkhali, Kushtia	T_1	115.75	38	28	22.5	91	29	22.85	435	8.70	20.75	4.01
	T_2	110	34	27	22.25	87	32	22.95	450	8.25	19.50	3.86

g. Field trials of USG Applicator in different locations during Boro/2013

Yield variation was observed in 21 studied locations between USG application and prilled urea application. In case of BRRI dhan28, average yield was found 5.95 and 5.78 ton/ha in USG and prilled urea plots respectively whereas 6.98 and 6.51 ton/ha yield was observed in BRRI dhan29 respectively. BRRI dhan50 also gave higher yield in the USG application plots compared to prilled urea plot which was 6.21 and 5.60 ton/ha respectively (Table 37). USG application gave around 0.35 ton/ha more yields than prilled urea. It might be due to produce higher effective tiller/m^2 as well as higher grains/m^2 resulted of higher yield (Table 38-40). Photographic view of field operations is shown in Apendix-F.

Table 37. Yield performance of BRRI varieties in different locations as affected by different method of urea application

Treatment	Average yield (t/ha)		
	BRRI dhan28	BRRI dhan29	BRRI dhan50
T_1	5.95	6.99	6.21
T_2	5.79	6.52	5.60

Table 38. Performance of yield and yield contributing parameters of BRRI dhan28

Place	Treat.	3-hills information						1000 grain weight (gm)	Tiller /20m^2	Paddy wt. of 20 m^2 (kg)	M.C. (%)	Yield at 14% m.c. (t/ha)
		Plant height (cm)	No. of plant	No. of panicle	Panicle length (cm)	No. of grains /panicle	Sterile grains /panicle					
Jatrapasha	T_1	92	47	39	25	118	24	22.45	420	15.00	22.00	6.80
Habiganj	T_2	89	39	33	24	120	23	22.55	426	14.60	22.00	6.62
Sutrapur	T_1	93	66	36	21	111	25	22.12	414	12.90	23.20	5.76
Rangpur	T_2	90	51	34	20.5	114	28	21.89	429	12.50	22.20	5.65
Gohalakanda	T_1	96	58	36	23	119	21	22.35	412	13.80	23.00	6.18
Purbadhala	T_2	92	56	32	22.4	123	27	22.21	419	13.00	22.00	5.90
Burichang	T_1	94	53	35	24	112	21	22.04	411	13.40	23.00	6.00
Comilla-1	T_2	90	55	35	23.2	114	24	22.21	419	12.90	23.00	5.78
Burichang	T_1	95	49	34	23	117	23	22.3	423	13.20	23.00	5.91
Comilla-2	T_2	90	53	32	22	114	28	22.4	429	12.80	22.00	5.80
Sadar	T_1	93	48	32	21.2	119	22	22.23	413	12.00	23.20	5.36
Habiganj	T_2	92	51	31	21	118	24	22.1	417	11.80	23.00	5.28
Sutrapur	T_1	89	49	33	23	113	21	22.53	421	12.90	22.70	5.80
Rangpur	T_2	87	52	33	22.2	117	26	22.2	426	12.30	21.70	5.60
Sadar	T_1	105	50	37	25.5	110	12	22.4	416	13.20	24.00	5.83
Kushtia	T_2	99	48	33	21.66	115	15	22.3	423	12.80	22.90	5.74
Laksam	T_1	93	53	35	23.2	112	9	22.32	411	13.00	23.50	5.78
Comilla	T_2	91	52	33	23	116	10	22.4	414	12.50	23.40	5.57
Burichan	T_1	102	57	34	25	113	22	22.53	422	13.40	23.00	6.00
Comilla-2	T_2	100	58	33	24	119	21	22.03	429	13.00	22.00	5.90
Mithapukur	T_1	88.8	62	38	21.5	102	29	22.3	423	13.40	22.00	6.08
Rangpur-1	T_2	85	59	36	21.4	107	24	22.012	435	13.00	23.00	5.82
Mithapukur	T_1	89	52	37	22.4	110	19	22.03	419	13.30	23.80	5.89
Rangpur-2	T_2	86	53	35	22	105	23	22.32	425	12.90	22.90	5.78

Table 39. Performance of yield and yield contributing parameters of BRRI dhan29

Place	Treat	3-hills information						1000 grain wt. (gm)	Tiller /20m^2	Paddy wt. of 20 m^2 (kg)	M.C. (%)	Yield at 14% m.c. (t/ha)
		Plant height (cm)	No. of plant	No. of panicle	Panicle length (cm)	No. of grains /panicle	Sterile grains /panicle					
Hislakor-1	T_1	94	52	37	24.6	124	24	23.34	419	16.00	23.30	7.13
Kumarkhali	T_2	90	44	36	23.29	118	24	23.74	422	15.60	23.00	6.98
Hislakor-2	T_1	93	50	38	25	125	29	23.22	414	16.20	22.30	7.32
Kumarkhali	T_2	91.5	40	34	23	121	22	23.42	428	15.40	23.00	6.89
Hislakor-3	T_1	99	52	37	23.5	115	19	23.65	417	15.50	23.80	6.87
Kumarkhali	T_2	96	50	33	23.19	127	24	23.24	426	14.90	23.40	6.64
Hislakor-4	T_1	93	57	36	23.9	121	27	23.7	421	16.00	23.00	7.16
Kumarkhali	T_2	90	50	35	23	117	25	23.56	424	14.90	23.00	6.67
Sadar	T_1	105	57	36	23.55	121	29	23.32	429	15.30	23.40	6.81
Netrakona	T_2	99	50	34	22.5	118	28	23.53	435	14.90	23.00	6.67
Purbadhala	T_1	90	53	37	22	120	9	23.09	424	15.60	23.00	6.98
Netrakona	T_2	89	54	36	22.2	100	15	22.12	410	12.00	24.00	5.30

Place	Treat	3-hills information						1000 grain wt. (gm)	Tiller /20m^2	Paddy wt. of 20 m^2 (kg)	M.C. (%)	Yield at 14% m.c. (t/ha)
		Plant height (cm)	No. of plant	No. of panicle	Panicle length (cm)	No. of grains /panicle	Sterile grains /panicle					
Burichang	T_1	95	51	35	25	121	24	23.17	432	15.00	24.00	6.63
Comilla	T_2	90	55	33	22	122	30	23.01	436	14.40	22.90	6.45

Table 40. Performance of yield and yield contributing parameters of BRRI dhan50

Place	Treat	3-hills information						1000 grain wt. (gm)	Tiller /20m^2	Paddy wt. of 20 m^2 (kg)	M.C. (%)	Yield at 14% m.c. (t/ha)
		Plant height (cm)	No. of plant	No. of panicle	Panicle length (cm)	No. of grains /panicle	Sterile grains /panicle					
Paba-1	T_1	97	48	35	22.9	117	20	22	413	12.90	22.10	5.84
Rajshahi	T_2	93	54	35	22.5	114	30	21.9	418	12.50	21.00	5.74
Paba-2	T_1	91	55	36	22.1	118	23	20.5	427	13.00	22.00	5.90
Rajshahi	T_2	90	52	33	22	112	30	21.1	432	12.00	21.70	5.46

II. Rice transplanter

a. Research station based trials of walking and riding type Rice Transplanter during Aus/2011

The field performance data of the transplanter is presented in Table 41. Field operation was found suitable in terms of spacing, depth of placement and uniformity of transplanting. The photographs of different field operations of walking and mechanical rice transplanter are presented in Appendix-G (Fig. G1 to G3).

Table 41. Field performance of the mechanical transplanter , Aus/2011

Parameters	Walking type rice transplanter	Riding type rice transplanter
Number of rows	4	6
Row to row distance (cm)	30	30
Transplanting speed (m/sec)	0.6 to 1.0	1.0 to 1.30
Field capacity (decimal/hr)	32.5 to 42.5	80 - 100
Fuel required (L/hr)	0.85	1.0
Transplanting width (cm)	120	180
Plant to plant distance (cm)	16	16
Transplanting depth (cm)	1.5-3.0	1.5-4.0
No. of plants per hill	3-6	3-6
No. of hill per m^2	20	20
Missing hill per m^2	1.5	1
Floating hill per m^2	1	1
Buried hill per m^2	1	1
Damaged hill per m^2	0	0
	Total missing hills=3.5	3

The average field capacity of the transplanter was found 37.5 decimal/hr and 90 decimal/hr. The field operation of this machine was found satisfactory. Transplanting of seedlings, placement of seedlings and depth of seedling placement were found satisfactory. Row to row distance and plant to plant distance was found uniform. Total missing hills were found 3.5 and 3.0 nos/m^2 considering missing, floating, buried and damage hills of walking and riding type transplanter respectively. The percent of total missing hills were 17.5 and 15%.

b. Field trials of Rice Transplanter in different locations during Aman/2011

Seedling was prepared in the farmers' field/yard with proper instruction. Farmers prepared their seedling both on polythene sheet and plastic tray. Plastic tray was supplied from project. Seedling from polythene sheet was cut using metallic frame similar with plastic tray in size (Appendix-H, Fig. H1). Raising seedling was carried in the field by making roll (Appendix-H, Fig. H4). Before field operation, discussion session was arranged with the help of DAE. Yield performance of rice transplanting by mechanical rice transplanter were compared with hand transplanting method. Machine transplanting plots gave more yields in all trials except Burichang, comilla. In Burichang, Comilla, 4.85 and 4.87 t/ha yield was found for machine and hand transplanting plots respectively. Average yield of the machine transplanting plot and hand transplanting plot were 4.95 t/ha and 4.85 t/ha (Table 42). Photographic view on rice transplanter field trials are presented in Appendix-H (Fig. H1 to H6).

Table 42. Information of the trial plots, Aman/2011

Locations	Date of transplan	Age of seedling days	Variety	M.T. area (decimal)	H. T. area (decimal)	Harvesting	Yield (t/ha)	
							M. Trans.	H. trans.
Kumarkhali Kushtia	16/08/2011	24	BRRI Dhan49	50	20	04/12/11	5.03	5.00
Sadar Kushtia	17/08/2011	25	BRRI Dhan49	45	15	04/12/11	5.12	4.85
Sadar Netrakona	10/08/11	22	BRRI Dhan49	50	30	29/11/11	5.05	4.99
Sadar Netrakona	11/08/2011	23	BRRI Dhan49	45	20	30/11/11	5.10	5.01
Laksam Comilla	08/08/2011	18	BRRI Dhan49	30	15	04/12/11	4.98	4.95
Purbadhala Netrakona	10/08/2011	22	BRRI Dhan32	40	15	29/11/11	4.28	4.25
Burichang Comilla	14/08/2011	21	BRRI Dhan49	40	25	07/12/11	4.85	4.87
Sadar Rangpur	11/08/2011	24	BRRI Dhan49	33	10	29/11/12	4.90	4.75
Paba Rajshahi	16/08/2011	26	BRRI Dhan49	35	15	04/12/11	5.06	4.98
Mithapukur Rangpur	10/08/2011	26	BRRI Dhan49	35	15	27/11/11	5.13	4.88
						Average yield (t/ha):	4.95	4.853

Note: MT = Machine transplanting and HT = Hand transplanting

Mechanical rice transplanter was evaluated in different ten locations of the country. During evaluation, average speed (m/sec), field capacity (deci/hr), fuel required (l/hr), transplanting width (cm), no. of plants per hill, no. of hill per m^2, missing hill per m^2, floating hill per m^2, buried hill per m^2 and damaged hill per m^2 were found 0.61, 41.0, 0.66, 120, 3-6, 20, 1.8, 0.8, 0.5 and 1.1 respectively. Average 4.2 nos/m^2 missing hills (19.5%) were observed during trials (Table 43).

Table 43. Field performance of the mechanical transplanter , Aman/2011

Parameters	Area (decimal)	[1]Time (min)	Avg speed (m/sec)	Field capacity (decimal/hr)	Fuel (l/hr)	T. width (cm)	Trans. depth (cm)	Missing hills/m^2	Floating hills/m^2	Buried hills/m^2	Damaged hills/m^2
Kumarkhali Kushtia	50	71.5	0.60	41.96	0.64	120	1.5-3.0	1	1	0	1
Sadar Kushtia	45	69	0.45	39.13	0.75	120	1.5-2.5	2	1	2	2
Sadar Netrakona	50	73.5	0.53	40.82	0.75	120	1.5-2.0	1	1	0	1
Sadar Netrakona	45	64.25	0.60	42.02	0.64	120	1.5-3.0	2	2	0	1
Laksam Comilla	30	40	0.53	45.00	0.64	120	1.5-2.0	0	1	0	1
Purbadhala Netrakona	40	64.5	0.60	37.21	0.64	120	1.5-3.5	2	1	1	1
Burichang Comilla	40	61.5	0.60	39.02	0.64	120	2.0-3.0	4	0	0	1
Sadar Rangpur	33	48.5	0.68	40.82	0.64	120	1.5-2.0	3	0	0	1
Paba Rajshahi	35	50	0.75	42.00	0.64	120	1.5-3.5	1	1	2	1
Mithapukur Rangpur	35	50	0.75	42.00	0.64	120	1.5-2.5	2	0	0	1
Average	-	-	0.61	41.00	0.66	120	-	1.8	0.8	0.5	1.1

[1]Transplanting time was counted considering turning, seedling feeding and operators personal times.

c. Field trials of Rice Transplanter in different locations during Boro/2012

Mechanical rice transplanter was evaluated in 11 different project locations during Boro/2012 season. Yield performance of rice transplanting by mechanical rice transplanter were compared with hand transplanting method. In all trials, machine transplanting plots gave more yield compare to manual transplanting plots except Paba, Rajshahi. Average yield of the machine transplanting plot and hand transplanting plot were 6.42 t/ha and 6.28 t/ha (Table 44).

Table 44. General information of Rice Transplanter trials during Boro/2011

Locations	Date of trans.	Seedling age (days)	Variety	M. T. area (decimal)	H. T. area (decimal)	Harvesting	Yield (t/ha)	
							M. Trans.	H. trans.
Kumarkhali Kushtia	17/01/12	28	BRRI Dhan29	35	15	23/05/12	7.17	7.15
Sadar Netrakona	23/01/12	25	BRRI Dhan29	40	10	29/05/12	6.87	6.85
Sadar Netrakona	24/01/12	26	BRRI Dhan29	42	25	30/05/12	7.05	7.00
Laksam Comilla	28/01/12	25	BRRI Dhan28	35	30	13/05/12	5.40	5.18
Purbadhala Netrakona	31/01/12	22	BRRI Dhan28	36	12	26/05/12	5.95	5.74
Burichang Comilla	05/02/12	24	BRRI Dhan50	40	20	23/05/12	6.00	5.85

Locations	Date of trans.	Seedling age (days)	Variety	M. T. area (decimal)	H. T. area (decimal)	Harvesting	Yield (t/ha)	
							M. Trans.	H. trans.
Sadar Habiganj	23/02/12	30	BRRI Dhan29	30	15	30/05/12	6.98	6.80
Sadar Rangpur	14/02/12	34	BRRI Dhan29	34	10	27/05/12	7.03	6.88
Mithapukur Rangpur	13/02/12	28	BRRI Dhan28	35	20	28/08/12	6.05	5.98
Godagari Rajshahi	24/01/12	26	BRRI Dhan28	35	20	10/05/12	5.97	5.50
Paba Rajshahi	16/01/12	28	BRRI Dhan29	32	10	15/05/12	6.12	6.14
						Average yield (t/ha):	6.42	6.28

Note: MT = Machine transplanting and HT = Hand transplanting

Table 45. Field performance of the mechanical transplanter , Boro/2011

Parameters	Area (decimal)	Time (min)	Avg. speed (m/sec)	Field capacity (decimal/hr)	Fuel (L/hr)	Trans. depth (cm)	Missing hills/m^2	Floating hills/m^2	Buried hills/m^2	Damaged hills/m^2
Kumarkhali, Kushtia	35	51.47	0.64	40.80	0.67	1.5-2.5	1	1	0	1
Sadar, Netrakona	40	58.82	0.53	40.80	0.80	1.5-3.0	0	1	2	0
Sadar, Netrakona	42	60.00	0.49	42.00	0.78	1.5-2.2	2	1	0	1
Laksam, Comilla	35	48.61	0.56	43.20	0.74	1.5-3.2	1	2	0	1
Purbadhala Netrakona	36	48.65	0.56	44.40	0.78	1.5-2.0	0	1	0	1
Burichang, Comilla	40	66.67	0.62	36.00	0.66	1.5-3.5	2	1	1	1
Sadar, Habiganj	30	48.39	0.64	37.20	0.68	2.0-3.0	4	0	0	1
Sadar, Rangpur	34	55.74	0.64	36.60	0.69	1.5-2.0	1	0	0	1
Mithapukur, Rangpur	35	51.47	0.83	40.80	0.70	1.5-3.5	1	1	2	1
Godagari, Rajshahi	35	53.85	0.71	39.00	0.72	1.5-2.5	2	0	0	0
Paba, Rajshahi	32	52.46	0.64	36.60	0.69	1.5-2.0	1	0	0	1
Average	-	-	0.62	39.76	0.72		1.36	0.73	0.45	0.82

Mechanical rice transplanter was evaluated in different 11 locations of the country. During evaluation, parameters on average speed (m/sec), field capacity (deci/hr), fuel required (L/hr), transplanting width (cm), no. of plants per hill, no of hill per m^2, missing hill per m^2, floating hill per m^2, buried hill per m^2 and damaged hill per m^2 were 0.62, 39.76, 0.72, 120, 3-5, 20, 1.36, 0.73, 0.45 and 0.82 respectively (Table 45). Photographic view on rice transplanter field trials are presented in Appendix-I (Fig. I1 to Fig. I4).

d. Field trials of mechanical Rice Transplanter in different locations during Aman/2012

Yield variation was observed in 11 studied locations between mechanical and manual transplanting. In case of BRRI dhan49, average yield was found 4.46 and 4.32 t/ha in mechanical and manual transplanting plots respectively whereas 3.84 and 3.77 t/ha yield was observed in BRRI dhan33 respectively. BINA dhan7 also gave higher yield in the mechanical transplanting plots compared to manual transplanting which was 3.77 and 3.69 t/ha respectively (Table 46). Mechanical transplanting gave around 0.15 t/ha more yields than manual transplanting. It might be due to produced higher effective tiller/m^2 as well as higher grains/m^2 resulted of higher yield (Table 47-49). Photographic view on rice transplanter field trials are presented in Appendix-J.

Table 46. Yield performance of BRRI varieties in different locations as affected by different method of transplanting

Treatment	Average yield (t/ha)		
	BRRI dhan49	BRRI dhan33	BINA dhan7
T_1	4.46	3.84	3.77
T_2	4.32	3.77	3.69

Table 47. Performance of yield and yield contributing parameters of BRRI dhan49 in different project locations

Place	Treat.	3-hills information						1000 grain wt. (gm)	Tiller /20m^2	Paddy wt. of 20 m^2 (kg)	M.C. (%)	Yield at 14% m.c. (t/ha)
		Plant height (cm)	No. of plant	No. of panicle	Panicle length (cm)	No. of grains /panicle	Sterile grains /panicle					
Laksam	T_1	94.5	41	30	22.5	108	32	20.65	425	9.5	19	4.47
Comilla	T_2	94	39	29	21.8	105	39	20.5	435	9.25	18.5	4.38
Burichang	T_1	98	44	31	21.6	106	29	20.78	420	10.25	20	4.77
Comilla	T_2	98	40	30	21.2	109	32	20.65	435	10.1	19.5	4.73
Nakla	T_1	102	42	28	21.5	111	37	20.42	425	9.5	19.5	4.45
Shrerpur	T_2	99.5	38	27	21	109	42	20.35	440	9.25	19	4.36
Sadar	T_1	100	40	30	22.4	102	35	20.5	425	9	20	4.19
Kushtia	T_2	99.5	37	27	22	106	32	20.45	430	8.5	20	3.95
Purbadhala	T_1	102.5	42	31	20.8	99	26	20.65	420	9.5	18.75	4.49
Netrakona	T_2	102.25	39	27	19.2	98	33	20.43	435	8.08	18.5	3.83
Sadar,	T_1	98.75	38	30	22.5	98	29	21.2	430	10.4	19.5	4.87
Rangpur	T_2	98	35	29	22.5	99	21	21.15	445	10.2	19	4.80
Mithapukur,	T_1	99	45	30	22	106	19	20.75	420	9.5	20	4.42
Rangpur	T_2	99.5	44	29	21.6	99	21	20.65	436	9.25	20	4.30
Sadar,	T_1	100	41	30	21.5	94	20	21.03	420	8.85	21	4.06
Habiganj	T_2	101	35	27	21	92	29	21	440	8.45	21	3.88
BRRI,	T_1	102	41	30	20.8	100	33	21.1	425	9.2	18	4.39
Gazipur	T_2	100.5	39	29	19.3	99	36	21	445	9	18	4.29

Table 48. Performance of yield and yield contributing parameters of BRRI dhan33 at Sadar, Netrakona

Place	Treat.	3-hills information						1000 grain wt. (gm)	Tiller /20m^2	Paddy wt. of 20 m^2 (kg)	M.C. (%)	Yield at 14% m.c. (t/ha)
		Plant height (cm)	No. of plant	No. of panicle	Panicle length (cm)	No. of grains /panicle	Sterile grains /panicle					
Sadar Netrakona	T_1	92	39	28	24	86	26	23.52	425	8.35	21	3.84
	T_2	94	33	27	22	83	27	23.48	440	8.2	21	3.77

Table 49. Performance of yield and yield contributing parameters of BINA dhan7 at Kumakhali

Place	Treat.	3-hills information						1000 grain wt. (gm)	Tiller /20m^2	Paddy wt. of 20 m^2 (kg)	M.C. (%)	Yield at 14% mc (wb) (t/ha)
		Plant height (cm)	No. of plant	No. of panicle	Panicle length (cm)	No. of grains /panicle	Sterile grains /panicle					
Kumarkhali Kushtia	T_1	112	40	27	22.9	91	29	22.85	420	8.2	21.0	3.77
	T_2	94	37	26	22.5	87	32	22.95	450	8.0	20.8	3.69

e. Performance evaluation of mechanical rice transplanter in un-puddled condition

Cone penetration resistance of soil before transplanting was measured using cone Penetrometer. The recorded data was presented in Fig. 28 to Fig. 30. Cone resistance was varied in three locations due to type of soil. In all cases, penetration resistance reading showed zero in the manometer dial up to 8cm in puddle condition. In the un-puddle condition, penetration resistance was around 1 Mpa at 8cm depth. However, penetration resistances were found 1.7, 1.9 and 2.05 Mpa at 22cm depth in the locations of Kumarkhali-Kushtia, Burichong-Comilla and Laksam-Comilla. In laksam-Comilla, resistance is more because of sandy loam soil.

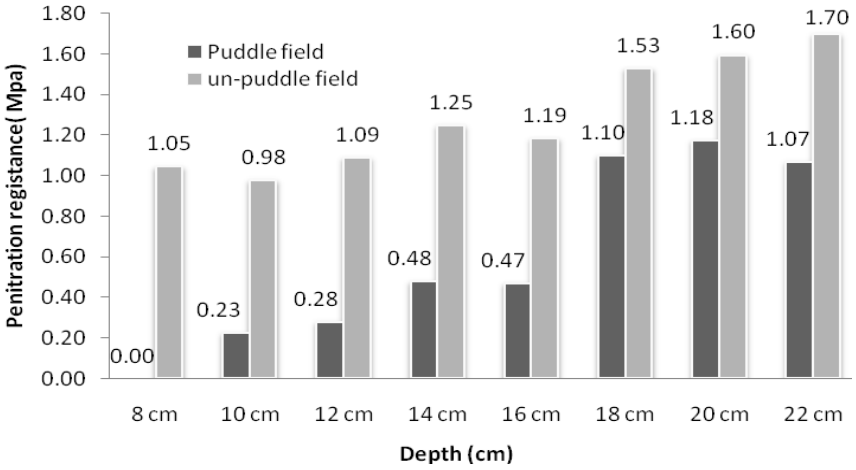


Fig.28. Cone penetration resistance of clay soil during transplanting at Kushtia

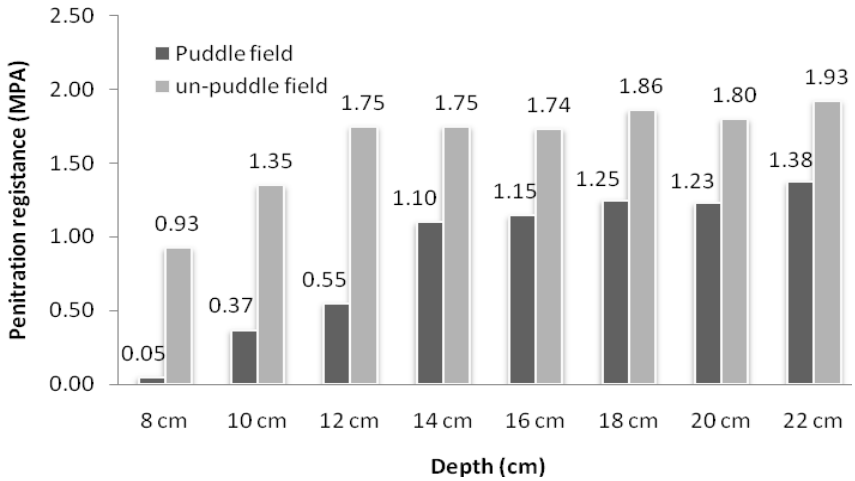


Fig. 29. Cone penetration resistance of clay loam soil during transplanting at Burichong

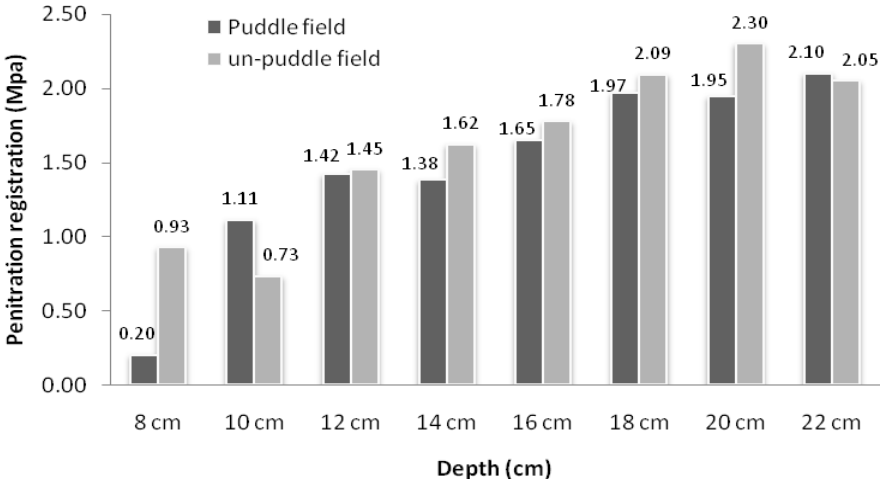


Fig. 30. Cone penetration resistance of sandy loam soil during transplanting at Laksam

Field performance of mechanical rice transplanter

Transplanter performance

Field performance of mechanical rice transplanter was measured in terms of field capacity and fuel consumption in both puddle and un-puddle field (Table 50). Field capacity of un-puddle transplanting was found less compare to puddle transplanting. Transplanter operation in un-puddle condition was new for the operator that might be the causes of less field capacity. Average, field capacity was found 0.14 ha/hr and 0.13 ha/hr in puddle and un-puddle field respectively. Average fuel consumption was found more in puddle field that was 5.28 L/ha whereas it was 4.77 L/ha in un-puddle field. Among the puddle and un-puddle field, fuel consumption was found more in clay type soil condition. More loads due to muddy soil during operation of mechanical rice transplanter in puddle field might be the causes of more fuel consumption.

Table 50. Field performance of the mechanical rice transplanter in both puddle and un-puddled condition

Parameters	Puddle field				Un-puddle field			
	Sandy loam soil	Clay loam soil	Clay soil	Avg.	Sandy loam soil	Clay loam soil	Clay soil	Avg.
Area under trials (ha)	0.142	0.129	0.154	0.14	0.073	0.081	0.061	0.07
Time of operation (hr)	0.95	0.9	1.25	1.03	0.58	0.62	0.45	0.55
Field capacity (ha/hr)	0.15	0.14	0.12	0.14	0.13	0.13	0.14	0.13
Fuel consumption (mL)	703	621	938	-	336	384	302	-
Fuel consumption (L/hr)	0.74	0.69	0.75	0.73	0.58	0.62	0.67	0.62

Note: Average of three replications

Transplanting performance

Transplanting performance of the mechanical rice transplanter in both puddle and un-puddle conditions were measured in terms of number of plants/hill, plant to plant distance, depth of planting, number of hills/m^2, number of trays/ha, missing hills/m^2, floating hills/m^2, buried hills/m^2 and damage hills/m^2. In puddle field, average plant to plant distance was found 14.42 cm whereas it was found 14.85 cm in un-puddle field. Slippage was the cause of reduced plant to plant distance in puddle field. On the other hand, transplanting depth almost same in both condition because of control depth of placing. Average total missing hills considering missing, floating, buried and damaged hills was found 3.60 and 4.92 hills/m^2 in puddle and un-puddle field respectively. Floating hills were observed more and buried hills less in un-puddle field. Total percent of missing hills were found more in un-puddle field in all locations due to more floating and damage hills. Floating hills may be reduced by operating the rice transplanter in the field with minimum standing water. Percent of missing hills in puddle and un-puddle conditions were 14.94 and 21.04. In both puddle and un-puddle conditions, % of total missing hills was observed more in clay soil condition and less in sandy loam condition (Table 51).

Table 51. Transplanting parameters of the mechanical transplanting in both puddled and un-puddled condition

Parameters	Puddle field				Un-puddle field			
	Sandy loam soil	Clay loam soil	Clay soil	Average	Sandy loam soil	Clay loam soil	Clay soil	Avg.
Plant to plant distance (cm)	14.75	14.5	14.0	14.42	15	14.80	14.75	14.85
Depth of transplanting (cm)	1.5-2.5	1.5-2.5	1.5-3.0	-	1.5-2.0	1.5-2.0	1.5-2.5	-
No. of hills/m^2	23.50	24.00	24.50	24.00	23.00	23.50	23.50	23.33
Missing hills/m^2	1.00	1.50	1.00	1.17	0.00	2.00	1.00	1.00
Floating hills/m^2	0.00	0.00	0.00	0.00	2.50	1.75	2.50	2.25
Buried hills/m^2	1.30	1.50	2.50	1.77	0.00	0.00	0.00	0.00
Damage hills/m^2	0.00	1.00	1.00	0.67	1.50	1.50	2.00	1.67
Total missing hills/m^2	2.30	4.00	4.50	3.60	4.00	5.25	5.50	4.92
% of total missing	9.79	16.67	18.37	14.94	17.39	22.34	23.40	21.04

Fig.31 . Mechanical rice transplanter operation in un-puddle and puddle fields

Yield performance

There was no significant yield variation observed in two tilling condition transplanting by mechanical rice transplanter in studied three locations except Burichong, Comilla (Table 52). In Burichong, yield was significantly higher when land was puddle conventionally before transplanting. In all the cases, higher yield was obtained in puddle condition than un-puddle condition. Although there was no significant difference in studied other two locations but puddle field gave around 0.13 t/ha more yield than un-puddle field. It might be due to produce higher effective tiller/m^2 as well as higher grains/panicles resulted of higher yield (Table 54 to 56).

Table 52. Yield in puddled and un-puddled conditions in three different locations

Treat	Yield (t/ha)			Average yield (t/ha)	
	Laksam Comilla	Burichong Comilla	Kumarkhali, Kushtia	BRRI dhan49	BINA dhan7
	BRRI dhan49	BRRI dhan49	BINA dhan7		
T_1	4.80a	5.40a	4.92a	5.1	4.92
T_2	4.76a	5.03b	4.88a	4.87	4.89
CV, %	8.22	1.71	6.08	-	-
$LSD_{0.05}$	1.374	0.31	1.048	-	-

There was no significant straw yield variation observed in three studied locations. However, in Laksam and Burichong, straw yield was obtained more in puddle field than un-puddle field. Average straw yield in puddle and un-puddle field was found 5.21 and 5.20 t/ha (Table 53).

Table 53. Straw yield in puddle and un-puddle conditions in different three locations

Treat	Straw yield (t/ha)			Average
	Sandy soil: Laksam	Clay loam soil: Burichong	Clay soil: Kumarkhali	
T_1	5.03	5.53	5.07	5.21
T_2	5.00	5.45	5.15	5.20
CV, %	1.63	6.82	1.06	-
Level of significant	NS	NS	NS	-

Yield parameters, Kumarkhali

There was no significance difference observed except 1000 grains within all yield contributing parameters. Plant height was found 102.6 and 102.3 cm for two treatments respectively. Average panicle length was 24.48 and 22.83 cm and tillers/m^2 was 361.7 and 404.3 nos. for T_1 and T_2 respectively. Average plant height, panicle length and tillers/m^2 were statistically identical in the both T_1 and T_2 . Number of effective tillers was 319.3 and 354.3 nos and filled grains/m^2 was 76.33 and 66.67 nos for T_1 and T_2 respectively whereas 1000 grains weight was 21.12 and 21.47 gm. 1000 grains weight was found significantly less in T_1. However, yield was 4.92 and 4.88 t/ha which was statistically identical for both in T_1 and T_2 (Table 54).

Table 54. Yield and yield contributing parameters, Kumarkhali, Kushtia

Treat.	Avg. plants height (cm)	Avg. Panicle length (cm)	Tiller/m^2	No. of effective tiller/m^2	Filled grain/ Panicle	Sterile grain/panicle	1000 grains weight at 14% m.c. (gm)	Yield at 14% m.c. (t/ha)
T_1	102.6a	24.48a	361.7a	319.3a	76.33a	30.67a	21.12b	4.92a
T_2	102.3a	22.83a	404.3a	354.3a	66.67a	25.67a	21.47a	4.88a
CV, %	1.70	3.30	13.22	4.60	4.67	11.50	0.44	6.08
$LSD_{0.05}$	6.113	2.742	177.9	54.48	11.74	11.38	0.3333	1.048

Yield parameters, Burichong

Significance difference was not observed in the yield contributing parameters. Plant height was found 104.7 and 96.33 cm for two treatments respectively. Average panicle length was 22.77 and 22.89 cm and tillers/m^2 was 395.3 and 333.7 nos. for T_1 and T_2 respectively. Average plant height, panicle length and tillers/m^2 were statistically identical in the both T_1 and T_2. Number of effective tillers was 277 and 253.7 nos and filled grains/m^2 was 98.0 and 99.33 nos for T_1 and T_2 respectively whereas 1000 grains weight was 20.50 and 20.53 gm. Effective tillers/m^2, filled grains/panicle and 1000 grains weight were found statistically identical in both cases. However, yield was observed significantly higher in T_1 compared to T_2 which was 5.4 and 5.03 t/ha respectively (Table 55).

Table 55. Yield and yield contributing parameters, Burichong, Comilla

Treat.	Avg. plants height (cm)	Avg. Panicle length (cm)	Tiller/m^2	No. of effective tiller/m^2	Filled grain/ panicle	Sterile grain/panicle	1000 grains weight at 14% m.c. (gm)	Yield at 14% m.c. (t/ha)
T_1	104.7a	22.77a	395.3a	277.0a	98.0 a	20.67a	20.5a	5.40a
T_2	96.33a	22.89a	333.7a	253.7a	99.3a	17.33a	20.5a	5.03b
CV, %	3.61	5.07	14.65	7.61	5.08	15.04	0.20	1.71
$LSD_{0.05}$	12.75	4.06	187.60	70.98	17.62	10.04	0.33	0.31

Yield parameters, Laksam

There was no significance difference observed in all yield contributing parameters. Plant height was found 94.63 and 86.33 cm for two treatments respectively. Average panicle length was 24.50 and 23.43 cm and tillers/m^2 was 287 and 315 nos. for T_1 and T_2 , respectively. Average plant height, panicle length and tillers/m^2 were statistically identical in the both T_1

and T_2 . Number of effective tillers was 235 and 239 nos and filled grains/m^2 was 102.3 and 100.3 nos for T_1 and T_2 , respectively whereas 1000 grains weight 20.12 and 20.10 gm. Effective tillers/m^2, filled grains/panicle and 1000 grains weight were found statistically identical in both cases. However, yield was 4.80 and 4.76 t/ha which is statistically identical in T_2 than T_1 (Table 56).

Table 56. Yield and yield contributing parameters, Laksam, Comilla

Treat.	Avg. plants height (cm)	Avg. Panicle length (cm)	Tiller/m^2	No. of effective tiller/m^2	Filled grain/ panicle	Sterile grain/panicle	1000 grains weight at 14% m.c. (gm)	Yield at 14% m.c. (t/ha)
T_1	94.63a	24.50a	287.0a	235.0a	102.3a	30.33a	20.12a	4.80a
T_2	86.33a	23.43a	315.0a	239a	100.3a	29.00a	20.10a	4.76a
% of CV	4.81	1.51	3.00	2.88	7.29	13.13	0.90	8.22
LSD value	15.29	1.276	31.72	23.96	25.94	13.68	0.6382	1.374

Cost-analysis

Cost analysis of the mechanical rice transplanter was done to find out the operating cost in terms of Tk/hr and Tk./ha in both puddle and un-puddle conditions. Operating cost in terms of fixed and variable cost was presented in Appendix-K (Fig. K1 & Fig. K2). Inputs cost for rice production in both puddle and un-puddle conditions are presented in Table 57. Benefit-cost ratio was computed based on total inputs cost including land rent and interest of investment, total production. Benefit-cost ratio computations are also presented in Table 58.

Table 57. Input cost of rice production as affected by tillage for transplanting using mechanical rice transplanter

Inputs	Puddle condition (Tk/ha)	Un-puddle condition (Tk/ha)	Comments
Seedling preparation	4800.00	4760.00	Number of trays in puddle field: 238/ha and un-puddle: 233/ha
Land preparation	10500.00	3750.00	Power tiller hired for making puddle
Transplanting	1844.00	1898.00	Based on operating cost of transplanter
Weeding	8400.00	11200.00	30 man-day/ha for puddle and 40 man-day/ha for un-puddle field
Herbicide and pesticide	1800.00	1800.00	Same for all plots
Supplement irrigation	1500.00	1500.00	One supplement irrigation applied.
Harvesting, carrying, threshing and winnowing	12500.00	12500.00	Same for all plots
Land rent	15000.00	15000.00	Land rent for one crop season @ Tk/ha=15000.00.
Interest on investment at the rate of 12%	6761.00	6289.00	
Total input cost	63105.00	58697.00	

Table 58. Benefit-cost ratio (BCR) calculation

Tillage option	Input cost (Tk/ha)	Gross return (Tk/ha)	Gross margin (Tk/ha)	BCR
Conventional tillage (Puddle condition)	63105	93927	30822	1.49
Zero tillage (Un-puddle condition)	58697	91640	32943	1.56

Note: Values are the means of three replications. Market price of straw (Tk/ton):1200.00 and Paddy (Tk/ton): 17500.00

BCR of rice production under puddle and un-puddle conditions, transplanting by mechanical transplanter, was gave 1.49 and 1.56 respectively. BCR of rice production in un-puddle condition was more compared to puddle condition in Aman season.

f. Field trials of mechanical Rice Transplanter in different locations during Boro/2013

Yield variation was observed in 21 studied locations between mechanical and manual transplanting. In case of BRRI dhan28, average yield was found 5.79 and 5.53 t/ha in mechanical and manual transplanting plots respectively whereas 6.92 and 6.41 t/ha yield was observed in BRRI dhan29 respectively. BRRI dhan50 also gave higher yield in the mechanical transplanting plots compared to manual transplanting which was 5.77 and 5.60 t/ha respectively (Table 59). Mechanical transplanting gave around 0.3 t/ha more yields than manual transplanting. It might be due to produce higher effective tiller/m^2 as well as higher grains/m^2 resulted of higher yield (Table 60-62). Photographic view of seedling raising on polythene sheet, discussion session, field operation in bed and conventional field during Boro/2013 is presented in Appendix-L.

Table 59. Yield performance of BRRI varieties in different locations as affected by different method of transplanting

Treatment	Average yield (t/ha)		
	BRRI dhan28	BRRI dhan29	BRRI dhan50
T_1	5.79	6.92	5.77
T_2	5.53	6.41	5.60

Table 60. Performance of yield and yield contributing parameters of BRRI dhan28

Place	Treat	3-hills information						1000 grain wt. (gm)	Tiller /20m^2	Paddy wt. of 20 m^2 (kg)	M.C (%)	Yield at 14% m.c. (t/ha)
		Plant height (cm)	No. of plant	No. of panicle	Panicle length (cm)	No. of grains /panicle	Sterile grains /panicle					
Jatrapasha	T_1	92	66	38	22.5	108	13	22.15	418	13.2	22.0	5.99
Habiganj	T_2	87	59	32	19.8	109	19	22.12	435	12	21.0	5.51
Sutrapur	T_1	87.5	62	35	20.8	102	26	22.65	412	12.8	23.5	5.69
Rangpur	T_2	84	59	37	19.2	100	43	22.43	427	13.25	21.8	6.03
Gohalakanda	T_1	92	44	35	24	111	16	23.521	416	13.5	22.5	6.08
Purbadhala	T_2	94	33	31	21	94	17	22.63	468	11.85	24.0	5.24
Burichang	T_1	94	53	36	25.5	100	19	22.53	419	12.4	24.5	5.44
Comilla-1	T_2	93	50	32	25	104	21	22.43	427	11.8	23.5	5.25
Burichang	T_1	98	45	34	24	116	19	22.4	428	13.5	24.0	5.97
Comilla-2	T_2	91	44	33	23.6	109	21	22.06	436	12.25	23.5	5.45
Sadar	T_1	90	48	35	19	107	10	22.03	418	12.56	23.0	5.62
Habiganj	T_2	90	35	31	16	102	20	22.12	440	12.1	22.5	5.45

Place	Treat	3-hills information						1000 grain wt. (gm)	Tiller /20m^2	Paddy wt. of 20 m^2 (kg)	M.C (%)	Yield at 14% m.c. (t/ha)
		Plant height (cm)	No. of plant	No. of panicle	Panicle length (cm)	No. of grains /panicle	Sterile grains /panicle					
Sutrapur	T_1	89	46	39	20.8	106	23	21.1	396	12.9	22.0	5.85
Rangpur	T_2	84	42	37	19.3	100	36	22.32	389	12	22.0	5.44
Sadar	T_1	96.33	53	36	27.55	117	25	22.152	400	12.4	20.0	5.77
Kushtia	T_2	92	51	35	23.5	115	26	22.12	410	12.1	20.0	5.63
Laksam	T_1	90	34	29	26	127	7	22.4	437	13.2	22.5	5.95
Comilla	T_2	89	33	30	25.7	121	8	22.5	449	12.85	22.0	5.83
Burichang	T_1	96	48	33	24	116	16	22.4	412	13	22.8	5.84
Comilla-2	T_2	95	44	30	23	123	20	22.35	426	12.3	22.0	5.58
Joyrampur	T_1	87.5	42	37	20.7	102	31	22.15	418	12.7	23.0	5.69
Rangpur-1	T_2	83	41	35	19.1	92	35	22.39	439	12	22.8	5.39
Joyrampur	T_1	96	54	34	24	113	21	22.45	419	12.6	23.0	5.64
Rangpur-2	T_2	93	53	34	22	110	26	22.4	426	12.25	22.0	5.56

Table 61. Performance of yield and yield contributing parameters of BRRI dhan29

Place	Treat	3-hills information						1000 grain wt. (gm)	Tiller /20m^2	Paddy wt. of 20 m^2 (kg)	M.C. (%)	Yield at 14% m.c. (t/ha)
		Plant height (cm)	No. of plant	No. of panicle	Panicle length (cm)	No. of grains /panicle	Sterile grains /panicle					
Hislakor Pu.	T_1	98	64	41	23.6	121	12	23.28	422	16.25	22	7.37
P Kumarkhali	T_2	92	53	36	21.2	119	16	23.02	438	14.9	21.5	6.80
Hislakor P.P	T_1	102	51	39	23	122	9	23.42	417	15.3	22.5	6.89
Kumarkhali	T_2	97	43	36	22.6	117	11	23.11	431	14	22	6.35
Hislakor D.P.	T_1	108	49	41	23.4	109	19	23.11	427	15.6	23	6.98
Kumarkhali	T_2	103	47	32	23	116	21	23.14	436	14.2	22.8	6.38
Hislakor	T_1	96	46	39	22.9	112	9	23.09	420	14.75	22.5	6.65
Kumarkhali	T_2	94	42	33	22.5	109	13	23.15	459	13.6	21.8	6.19
Sadar,	T_1	115	47	34	24	117	26	23.9	432	14.8	23	6.63
Netrakona	T_2	99	46	32	22.5	114	10	23.36	438	14.25	23	6.38
Purbadhala,	T_1	105	47	37	24	119	16	23.54	417	14.25	20	6.63
Netrakona	T_2	102	35	31	21	110	19	23.06	469	12.6	20	5.86
Mohishvanga,	T_1	95	51	36	26	128	24	23.25	424	16.3	23	7.30
Comilla	T_2	93	43	32	23	124	30	23.65	452	15.4	23	6.89

Table 62. Performance of yield and yield contributing parameters of BRRI dhan50

Place	Treat	3-hills information						1000 grain wt. (gm)	Tiller /20m^2	Paddy wt. of 20 m^2 (kg)	M.C. (%)	Yield at 14% m.c. (t/ha)
		Plant height (cm)	No. of plant	No. of panicle	Panicle length (cm)	No. of grains /panicle	Sterile grains /panicle					
Paba-1	T_1	97	49	35	23	121	13	21	412	13.25	23.5	5.89
Rajshahi	T_2	94	57	37	23.5	113	15	21.02	409	12.8	23	5.73
Paba-2	T_1	93	48	39	22	106	16	21.5	417	12.7	23.6	5.64
Rajshahi	T_2	89	53	34	21.3	104	11	21.45	435	12.2	23	5.46

g. Modification of riding type mechanical rice transplanter for un-puddle transplanting

An initiative was taken to modify the mechanical rice transplanter for un-puddle transplanting. Design of the strip tillage mechanism and power transmission system was done using AutoCAD tools. Chain sprocket arrangement was used to transmit the power from engine to rotary shaft. Engine power was transmitted to the rotary shaft of strip tillage by reducing the power in three stages. Strip tillage mechanism was attached before the rotary picker. Considering rated RPM of 3600, strip tillage shaft RPM is 477. Considering 3200 and 3000 RPM of the engine, strip tillage rpm is 424 and 398 (Table 63). The RPM of the strip tillage shaft found suitable to make strip in the field in un-puddle condition. Modification and fine tuning works is going on in the research workshop. During test in the soil bin bed of FMPHT division, 3.85 cm and 2.65 cm width and depth of strip was found. It can be changed with tine arrangement. Details drawing of different components for strip tillage arrangement and fabrication views are shown in Appendix-M (Fig. M1 & Fig. M2).

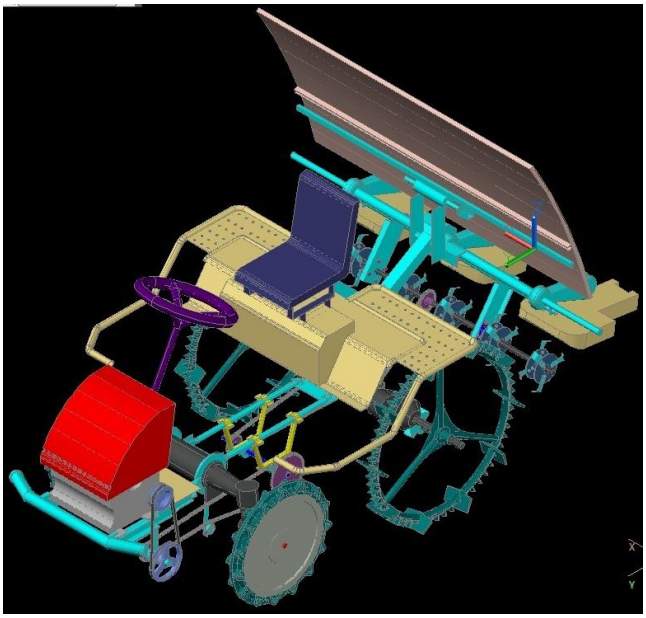


Fig.32. Complete view of the drawing (Isometric view)

Table 63. RPM calculation of different shaft for power transmission

Engine RPM	1st shaft RPM	2nd shaft RPM	1st shaft RPM	Strip tillage shaft RPM
3600	12.75/20.35*3600=2255	23/50*2255=1037	23/50*1037=477	23/23*477=477
3200	12.75/20.35*3200=2005	23/50*2005=922	23/50*922=424	23/23*424=424
3000	12.75/20.35*3000=1880	23/50*1880=865	23/50*865=398	23/23*398=398

h. Development of seedling raising technique for mechanical rice transplanter, Boro/2010

The number of seedling per square centimeter, fresh and dry weight of seedling were taken and therefore calculate seedling strength for each treatment. The highest seedling strength was found for T14 (227.22) treatment followed by T5, T6, and T2 treatments respectively. The lowest seedling strength was found for T13 (86.47) treatments followed by T3, and T9 respectively (Table 64). Therefore, T14 treatment seedling is suitable for machine transplanting. This is the first year one rice season data and there are some ambiguities among the results. The experiment will be repeated in several rice seasons to get better results.

Table 64. Agronomic characteristic of seedling raised in different method

Treatment	No. of plant/cm^2	Ave. Fresh wt (gm)	Ave. Dry wt. (gm)	wt. difference (gm)	Ave. height of 10 plant (cm)	Seedling strength (mg/cm^2)
T1	6.00	8.84(76)	7.10	1.74	98.2	120.50
T2	4.94	8.12(79)	6.42	1.7	88	147.68
T3	5.50	8.79(88)	6.87	1.92	128	97.59
T4	5.44	8.47(87)	6.54	1.93	86.5	138.98
T5	5.56	8.70(89)	6.77	1.93	80	152.20
T6	5.12	8.08(82)	6.53	1.55	85.5	149.17
T7	6.38	9.77(102)	7.77	2.0	114.5	106.36
T8	6.19	7.66(99)	6.33	1.33	97	105.42
T9	6.63	9.60(106)	7.02	2.58	107	98.96
T10	4.69	9.47(75)	7.15	2.32	106.5	143.15
T11	5.88	8.59(94)	6.83	1.76	96.5	120.37
T12	4.94	8.92(79)	6.87	2.05	108.5	128.17
T13	6.50	8.96(104)	6.66	2.30	118.5	86.47
T14	3.50	7.62(56)	6.72	0.90	84.5	227.22

i. Development of seedling raising technique for mechanical rice transplanter

The number of seedling per 25 square centimeters, fresh and dry weight of seedling were taken and therefore calculate seedling per square centimeter for each treatment. The highest no. of seedling per square centimeter was found for T_9 (4.25) treatment followed by T_{13} and T_7 treatments respectively. The lowest no. of seedling was found for T_{14} (2.24) treatments followed by T_{10}, and T_1 respectively (Table 65). The seedling height should be 10-12cm with 3-4 leaves, 4-5 seedling per square centimeter and a 2.0 – 2.5 cm soil thickness are appropriate for machine transplanting. Therefore, T_9 treatment seedling is more suitable for machine transplanting. This is the two rice season data and there are some ambiguities among the results. The experiment will be repeated in several rice seasons to get better results.

Table 65. Agronomic characteristic of seedling raised in different method

Treatment	No. of seedling/ 25 cm^2	Ave. Dry wt. (gm)	Ave. Dry wt (mg)	Ave. height of 10 plant (cm)	Avg. height (cm)	No. Seedling /cm^2
T_1	76	7.1	7100	98.2	9.82	3.04
T_2	79	6.42	6420	88.0	8.8	3.16
T_3	88	6.87	6870	128.0	12.8	3.52
T_4	87	6.54	6540	86.5	8.65	3.48
T_5	89	6.77	6770	80.0	8	3.56
T_6	83	6.53	6530	85.5	8.55	3.32
T_7	102	7.77	7770	114.5	11.45	**4.08**
T_8	99	6.33	6330	97.0	9.7	3.96
T_9	106	7.02	7020	107.0	10.7	**4.25**
T_{10}	75	7.15	7150	106.5	10.65	3.00
T_{11}	94	6.83	6830	96.5	9.65	3.76
T_{12}	79	6.87	6870	108.5	10.85	3.16
T_{13}	104	6.66	6660	118.5	11.85	**4.16**
T_{14}	56	6.72	6720	84.5	8.45	2.24

III. Training on Seedling raising techniques for mechanical transplanting and operation & maintenance of Rice transplanter and USG Applicator

A total of 11 hands on training on "Seedling raising techniques for mechanical rice transplanter and operation & maintenance of farm machinery" were conducted with different categories of farmers, manufacturer and traders with the help of Department of Agricultural Extension (DAE). 220 farmers were skilled directly on seedling raising for mechanical transplating. Trainees were also skilled on operation & maintenance of USG Applicator and RT. Farmers will be able to operate and maintain USG applicator and rice transplanter in the field. Photographic views on training program (different training activities) are shown in the following Fig. 33-36.

Fig.33. Theoretical discussion session

Fig.34. Hands on trining on tray preparation and seed sowing

Fig.35. Practical discussion session

Fig.36. Seedling raising on polythene sheet

IV. Large scale validation trials of USG applicator and rice transplanter during Boro/2013

a. USG Applicator

Large scale validation trials were conducted in all project location. Under this activity, a total of 316 trials were conducted with the help of DAE. A total of 316 farmers of the project locations were directly benefited under this activity. Total area of 8847 decimal equivalent of 35.82 ha area were cultivated using BRRI USG applicator. Total 5946 kg USG fertilizer were used in the cultivated area that was saved 3875kg of urea fertilizer compared to prilled urea (Table 66). Equivalent price of saved fertilizer is Tk. 85250/-. During operation, farmers comment were also collected form field about machine operation. The summarized precondition of USG applicator using in the field is as follows:

- Line transplanting maintain spacing 18 x 20, 20 x 20 and 22 x 20 is required
- Applicator should be operated by pushing force. Pulling create blockage of granule dispensing channel by mud.
- During field operation, minimum standing water (0.5-1.0cm) should be maintained for smooth operation.
- Standing water also have to be maintained in the field after rice transplanting till the date of USG application to keep the soil soft that helps the smooth operation by opening and closing the furrow properly.
- Applicator should be operated in the field as early as possible after transplanting (with 5 days).
- Applicator should be operated in the field before settling of the soil of the transplanted field
- Only 2/3 portion of the granule tank have to fill up by USG during field operation

Table 66. Result of large scale validation trials of USG applicator

Sl. No.	Location	Number of trials	Number of farmers benefited	Area (decimal)	Amount of USG used, (kg)	Urea fertilizer saved (kg)
1	Baniachang, Habiganj	26	26	833	365	365
2	Sadar, Habiganj	26	26	867	380	380
3	Laksam, Comilla	18	18	548	240	240
4	Burichang, Comilla	26	26	444	194	194
5	Sadar, Netrakona	25	25	417	183	183
6	Purbadhala, Netrakona	25	25	802	351	351
7	Sadar, Rangpur	08	08	195	85	85
8	Mithapukur, Rangpur	52	52	1005	440	440
9	Paba, Rajshahi	18	18	396	173	173
10	Gudagari, Rajshahi	12	12	399	175	175
11	Sadar, Kushtia	26	26	828	363	363
12	Kumarkhali, Kushtia	54	54	2113	926	926
Total		316	316	8847	5946	3875

b. Rice transplanter

Large scale validation trials of mechanical rice transplanter were conducted in five project location. Under this activity, a total of 47 trials were conducted with the help of DAE. A total of 47 farmers of the project locations were directly benefited under this activity. Total area of

2062 decimal equivalent of 8.35 ha areas were cultivated using mechanical rice transplanter (Table 67). During field trials of mechanical rice transplanter, the following preconditions were recorded for successful operation of the rice transplanter.

- The field should be leveled for better performance of rice transplanter and uniform crop establishment
- Settling time after preparing the field and water level in the field are the key factors for the success of the mechanical rice transplanting
- After final leveling, allow the soil to settle for 12–24 hours.
- Sufficient bearing strength of soil is necessary to carry the machine and support the planted seedlings
- Avoid use of transplanter in low land ecologies where water remains stagnant
- Maintain only 1 cm water or saturated condition while transplanting
- Immediately after transplanting irrigation sometimes disturbs the seedlings
- Seedling should be uniform density and standard height.

Table 67. List of large scale validation trials of rice transplanter

Sl. No.	Location	Number of trials	Number of farmers benefited	Area (decimal)
1	Hislakor, Kumarkhali	29	29	1399
2	Hasimpur, Kumarkhali	3	3	75
3	Moragacha, Kumarkhali	3	3	190
4	Burichang, Comilla	5	5	165
5	Sadar, Netrakona	4	4	128
6	Sadar, Rangpur	3	3	105
Total		47	47	2062

11. Research Highlights

a. A USG applicator was designed, fabricated and tested with adjustable facilities for 18 cm, 20 cm and 22 cm line to line and 20 cm plant to plant spacing. The depth of placement was 6-7 cm.

b. The weight and average field capacity of the USG applicator is about 7.5 kg and 33.75 decimal/hr respectively.

c. Urea fertilizer was saved 112 and 55 kg/ha using the applicator in Boro and Aman season respectively. The labor of 7 man-day/ha was also saved.

d. Walking and riding type mechanical rice transplanter were evaluated in different soil condition to identify the problems and troubleshooting mechanisam were developed during field operation. Average field capacity of the walking and riding type transplanter was found 39.42 and 90 decimal/hr respectively.

e. Total percent of missing hills including missing, floating, buried and mechanically damaged hills were 16.47% and 15% for the walking and riding type transplanter respectively based on different soil, water and seedling condition. Missing, floating, buried and damaged hills widely varied due to seedling density, seedling quality, field conditions, standing water and setling period of soil after final land preparation.

f. The walking type rice transplanter was also evaluated in both puddled and un-puddled conditions. Total missing percentage of hills was found to be 14.94 and 21.04 and field capacity was found 34.58 and 32.11 decimal/hr for puddled and un-puddled conditions respectively.

g. Seedling raising techniques on plastic tray and polythene sheet was developed for mechanical rice transplanting.

h. Users opined that the BRRI USG applicator is suitable as urea fertilizer and labor saving technology. They also comment that the operation of USG applicator is easier and less drudgeries. Farmers also found suitable to operate mechanical rice transplanter in both puddle and un-puddled conditions though they still faceing problems to raise seedling during Boro season because of heavy cold. Entrepreneurship development for seedling rising might be solved the problems of mechanical transplanter popularization in Bangladesh.

12. Major Attainments

a. Technical: Output, Outcome and Impact

Sl. No	Major technical activities performed in respect of the set objectives	Output (i.e product obtained, visible, measurable)	Outcome(short term effect of the research)	Impact (long term effect of the research)	Remarks (reason, if anything otherwise plus any other)
1.	• Design and fabricated of USG Applicator	• Metallic and plastic version of USG applicators were developed with adjustable facility of 18/22/22 cm of line to line distance and 20 cm plant to plant distance. • Another version of USG applicator was also design for mechanical rice transplanting field	• User friendly effective USG applicator will be available in the project area.	• Fertilizer use efficiency will be increased 10 to 20%. • Rice production cost will be decrease 15 to 20%. • Rice production will be increased 10 to 15%.	
1.	• Procured developed USG applicators	• 100 USG applicators were procured from manufacturer and distributed to the farmers in the project area under DAE for large scale validation.	• Farmers will be habituated with the technology • Awareness will be buildup on USG technology and USG applicator • Drudgery of manual USG placing will be reduced	• USG application in the rice field will be mechanized	
2.	• Collected walking and riding type mechanical rice transplanter (RT)	• 2 walking type and 2 riding type mechanical rice transplanter was collected under the project	• Mechanical rice transplanter will be available for further research in Bangladesh context.	• Research knowledge/ capacity on mechanical rice transplanter will be increased for transplanting mechanization	
2.	• Problems identified and rectified of the mechanical rice transplanter	• Field level problems RT operation were identified • Troubleshooting mechanism of RT were developed • Brochure was developed on field problems and troubleshooting mechanism of RT.	• Farmers will get information on operation and maintenance of mechanical rice transplanter • Awareness on mechanical rice transplanter will be increased	• Rice transplanting will be mechanized in Bangladesh	
2.	• Developed of mechanical rice transplanter	• Rice transplanter was developed for un-puddle transplanting	• Owner of the mechanical rice transplanter will	• Tillage cost for rice production will be saved as well as	Design is completed and

		• Strip tillage mechanism was added in the rice transplanter to make small strip for un-puddle transplanting	be able to transplant rice in un-puddle condition	production cost without sacrifice yield.	fabrication is under process.
2.	• Developed seedling raising techniques	• Seedling raising on plastic tray and polythene sheet techniques were developed for mechanical rice transplanter	• Seedling raising problems for mechanical transplanter will be removed.	• Seedling raising for mechanical rice transplanter will be commercialized. • Entrepreneurship on seedling raising will be developed in the farmer's level.	
3.	• Conducted field trials of USG Applicator	• Total 19 research station based trials and 51 farmers' field based trials were conducted in the project locations throughout the project period • 320 large scale validation trials were also conducted in the farmers' field. • Around 12000 farmers directly awarded about the technology of USG and USG Applicator • Under the trials, about 60 hectors rice area was covered and 6.6 ton of urea saved which equivalent value is about Tk. 1600000.00	• USG applicator technology will be adopted in the project areas • Farmers will be able to save urea fertilizer • Drudgery of manual placing of USG will be reduced.	• USG application by applicator will be ensured in rice production • Fertilizer use efficiency will be increased.	
3.	• Conducted field trials of mechanical rice transplanter	• Total 08 research station based, 66 validation trials and 35 large scale validation trials of rice transplanter were conducted during the project period. • Under the trials, about 23.5 hectors area was covered and money saved around Tk. 11.75 lac compare to manual transplanting • About 8000 farmers directly awarded on mechanical transplanting	• Technology will be adopted in the project areas • Rice transplanting will be mechanized in the project area • Drudgery of planting will be minimized • Timeliness of rice planting will be ensured • Planting cost will be reduced	• The yield loss due to delayed planting will be minimized • Turn-around time will be reduced • Cropping intensity will be increased	

4.	• Conducted hands on training on Seedling raising and operation & maintenance of Applicator and RT	• Total 11 training was conducted during the project period • 220 farmers was skilled on seedling raising of mechanical rice transplanter • Trainees also skilled on operation & maintenance of USG Applicator and RT	• Farmers will be able to operate and maintain USG applicator and rice transplanter • Seedling raising problems will be removed for mechanical rice transplanter	• Technology will be adopted in the project area • Entrepreneurship on seedling raising will be developed	

b. Procurement

Sl. No	Approved provisions of Procurement (list major items)	Achievements	% of achievements	Remarks
1	Procurement of furniture (Table-06, Chair-06, Almira-02, File cabinet-02).	Procured	100%	
2	Procurement of digital tachometer (01), digital camera (01) and scanner (01)	Procured	100%	
3	Procurement of computer (02)	Procured	100%	
4	Procurement of USG applicator (100)	Procured	100%	
5	Procurement of seating and walking type rice transplanter (walking-02 and riding-0 2)	Procured	100%	
6	Procurement of motor cycle (01) and bicycle (02)	Procured	100%	

c. HRD/ Training

Title (e.g. PhD/MS/ Trainings, workshops conducted etc.)	Target	Attainments	No. of participants	Benefit of the higher studies/trainings (application of the learning, productivity enhancement	Remarks (reason, if anything otherwise)
Training on "Seedling raising techniques for mechanical transplanting and operation & maintenance of Rice transplanter and USG Applicator"	11	11	220 nos	• Trainees were skilled on operation & maintenance of USG Applicator and RT adequately. • They are also able to raise seedling for mechanical rice transplanter as par specifications. • It may help them to develop entrepreneurship on seedling raising.	
"Research review workshop" on project activities	01	01	150	• Project activities was presented before the participants • Information regarding developed technology were disseminated to the different stakeholder • Recommendations were drawn for future research. • Most of the participants and resource persons gave emphasis to popularize the developed technologies through quality manufacturing with proper inspections.	

d. Financial

Sl. No	Major Head	Fund received (Tk.)	Expenditure (Tk.)	Balance/Unspent (Tk)	Remarks
1	A. Salary & Remuneration	1172021	1020541	137864	
2	B. Research expenses	3362475	3411047	-48695	
3	C. Operating expenses	741346	736439	6531	
4	D. Vehicle hire and Fuel, Oil & Maintenance	1038941	1061690	-27459	
5	E. Workshop/Seminar etc.	401728	413166	0	
6	F. Publications & printing	338444	299680	35151	
7	G. Contingencies	465217	470410	3807	
8	H. Capital expenses	3733546	3733546	0	
9	Total	**11253718**	11146519	107199	

e. Materials developed/Publications made

Type of material/publication	Title	No.	Remarks
Technology development	• USG applicator for manual transplanting field	120	Distributed to the farmers through DAE for large scale validation
	• USG applicator for mechanical transplanting field	05	04 copies were distributed to the farmers
	• Un-puddle transplanting mechanism using rice transplanter	-	Knowledge distributed to the farmers and respective stakeholder
	• Seedling raising technology	-	do
Journal publication	• Publication under process in the Journal of FMP department of BAU on USG applicator and Transplanter performance	02	
Books/Monographs/Manual published	-		
Booklet/leaflet/flyer etc. published	• Leaflet on BRRI USG applicator • Seedling raising techniques for mechanical rice transplanter. • Mechanical rice transplanter operation and troubleshooting.	5000 (each)	Around 4000 copies were distributed to the end users.
Any other(patenting of technology etc.)	• PVC board poster on BRRI USG applicator	06	03 were distributed.

13. Sub-project Auditing

Types of Audit (e.g. BARC/Implementing agency/FAPAD/World Bank/others)	Major observations/issues/objections raised, if any	Status at the sub-project end	Remarks
World Bank	No objections were raised	-	Total three times audits were done
FAPAD	No objections were raised	-	

14. Reporting

Report type	Actual date of submission(s)	Total No. (s)	Remarks
a. Inception report	04/08/2010	01	
b. Monthly reports*	19/8/10, 05/09/10, 11/10/10, 9/11/10, 14/12/10, 4/01/11, 8/2/11, 8/03/11, 8/04/11, 11/05/11, 05/06/11, 8/07/11=12 16/08/2011, 08/09/11, 10/10/11, 22/11/11, 15/12/11, 08/01/12, 07/02/12, 04/03/12, 05/04/12, 03/05/12, 18/06/12, 15/7/12 =12 10/07/12, 7/8/12, 3/9/12, 8/11/12, 8/11/12, 10/12/12, 7/1/13, 10/02/13, 11/3/13, 15/4/13, 08/05/13, 13/6/13=12 15/7/13, 21/8/12, 08/09/13, 06/10/13, 20/11/13, 11/12/13	42	Up to November /13
Statement of expedites.(SoE)*	do	42	do
d. Quarterly report(s)*	14/12/10, 26/04/11, 10/10/11, 30/04/12, 03/05/12, 15/4/13, 23/10/13	07	do
e. Six monthly report	16/01/2011, 26/01/12, 24/1/13	03	do
f. Procurement plan	04/08/10, 14/12/10, 27/12//10	03	
g. Annual research program format	24/08/10	01	
h. Environmental monitoring (Annual Basis)	-		
i. Social safeguard status (Before and at the end)	-		
j. Field Monitoring Report(s)**	03/04/11, 05/01/12, 05/05/13	03	

* Provide all since start to end.

** Conducted at the local level by implementing agencies.

15. Problèmes/ Contraints

- Reporting of the project was too many.
- Quarterly report rather than monthly report might be helpful to conduct the project activities in time.
- Delay of fund disbursement also hampered to implement the project activities in time.

16. Suggestion for future, if any :

- Large scale research and development program on USG applicator and rice transplanter needs to be executed.
- Developed USG applicator technology needs to be disseminated through building up of researcher-manufacturer-extension linkage.
- Govt. level farm machinery manufacturing industries needs to be developed for quality machine production like Japan, Korea etc.
- Capacity of local manufacturers needs to be strengthened with technical assistance, skill training for quality production.
- Subsidy needs to be provided to the end user (farmers group) for rapid adaptation of USG applicator and rice transplanter.
- Before dissemination of the technology, appropriate training on operation and repair & maintenance needs to be provided to the farmers and entrepreneurs.
- Similar project needs to be implemented with more stakeholders covering all districts of Bangladesh.

Signature of the Coordinator/Principal Investigator (as applicable)
Date …….
Seal

Counter signature of the Head of the agency/authorized representative
Date ……..
Seal

Appendix-A

Photographic view of USG and USG applicator

Fig. A1. Available size of USG/UMG granules

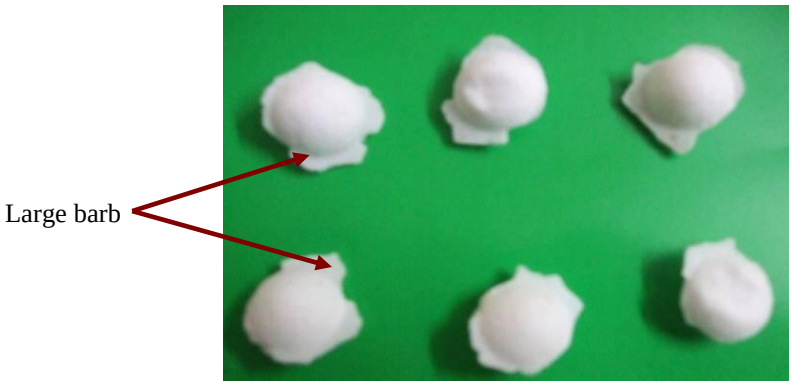


Fig. A2. USG granules with barb

Fig. A3. BRRI modified USG Applicator

Fig. A4. BRRI USG Applicator (1st version)

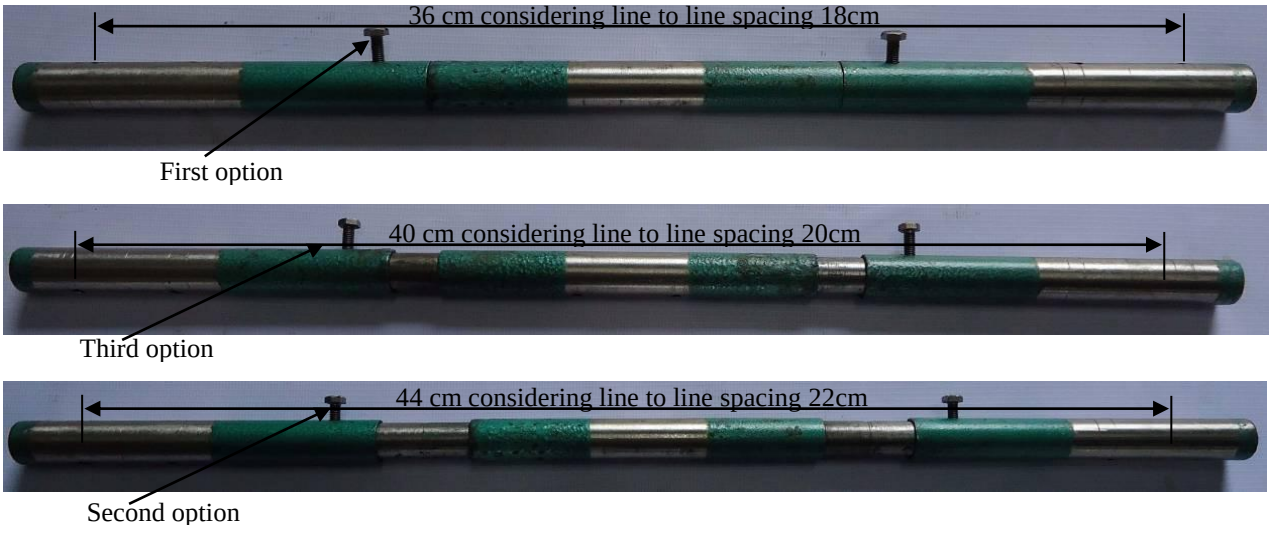


Fig.A5. Three options in the main axle to adjust the width of the applicator

Appendix-B

Photographic view of USG applicator trials in different locations during Aman/2010

Fig. B1. Field trial in Rangpur, 2010

Fig. B2. Field trial in Gazipur, 2010

Fig. B3. Field trial in Kushtia, 2010

Fig. B4. Field trial in Netrakona, 2010

Appendix-C

Photographic view of USG applicator trials in different locations during Boro/2011

Fig. C1. Field operation of USGA at Akkelpur, Rangpur

Fig. C2. Field operation of USGA at Sutrapur, Rangpur

Fig. C3. Field operation of USGA at Sadar, Kushtia

Fig. C4. Field operation of USGA at Kumarkhali, Kushtia

Fig. C5. Discussion with farmers at Baniachang, Habiganj

Fig. C6. Field operation of USGA at Sadar, Habiganj

Fig. C7. Field operation of USGA at BRRI R/S, Habiganj

Fig. C8. Disscussion with farmers at Buricang, Comilla

Fig. C9. Field operation of USGA at Laksam, Comilla

Fig. C10. Discussion with farmers at Purbadhala, Netrakona

Fig. C11. Field operation of USGA at Sadar, Netrakona

Fig. C12. Field operation of USGA at Paba, Rajshahi

Fig. C13. Crop condition of USGA trial plot at Sadar, Netrakona

Fig. C14. Crop condition of USGA trial plot at Purbadhala, Netrakona

Fig. C15. Crop condition of USGA trial plot at Kumarkhali, Kushtia

Fig. C16. Crop condition of USGA trial plot at Sadar, Kushtia

Fig. C17. Crop condition of USGA trial plot at Baniacang, Habiganj

Fig. C18. Crop condition of USGA trial plot at BRRI, R/S, Habiganj

Appendix-D

Photographic view of USG Applicator trials in different locations during Boro/2012

Fig. D1. Field operation of USGA at Habiganj

Fig. D2. Discussion with farmers at Kumarkhali

Fig. D3. USGA distribution for large scale validation

Fig. D4. Field operation of USGA at Netrakona

Appendix-E

Photographic view of USG Applicator trials in different locations during Aman/2012

Fig. E1. Observing field operation of USGA

Fig. E2. Field operation of USGA at Kumarkhali

Fig. E3. Field operation of USGA at Habiganj

Fig. E4. Field operation of USGA at Mithapukur

Appendix-F

Photographic view of USG Applicator trials in different locations during Boro/2012

Fig. F1. Discussion with farmers at Laksam

Fig. F2. Field performance test at Gazipur

Fig. F3. Field operation at Kumarkhali

Fig. F4. Field operation at Netrakona

Fig. F5. Field operation at Habiganj

Fig. F6. Field operation at Rangpur

Appendix-G

Field operation of walking and riding type rice transplanter during Aus/2011

Fig.G1.Field operation of walking type rice transplanter during Aus 2011

Fig.G2. Operation of the riding type rice transplanter in dry condition

Fig.G3. Field operation of the riding type rice transplanter during Aus 2011

Appendix-H
Photographic view of rice transplanter trials during Aman/2011

Fig. H1. Seedling raising on polythene sheet

Fig. H2. Seedling raising on plastic tray

Fig. H3. Discussion session on rice trasplanter

Fig. H4. Seedling carrying in the field by rolling

Fig. H5. Field operation in Sadar, Netrakona

Fig. H6. Field operation in Kumarkhali, Kushtia

Appendix-I

Photograph of rice transplanter trials during Boro/2012

Fig. I1. Seedling raising on polythene sheet

Fig. I2. Seedling raising on plastic tray

Fig. I3. Field operation at Sadar,Netrakona

Fig. I4. Discussion on rice trasplanter at Burichang

Appendix-J
Photograph of rice transplanter trials during Aman/2012

Fig. J1. Preparation for seedling raining on polythene sheet

Fig. J2. Seedling raining on polythene sheet

Fig. J3. Executive Chairman of BARC observing the field trial

Fig. J4. Field trials at Laksam, Comilla

Fig. J5. Crop cut at Kumarkhali, Kushtia

Fig. J6. Field trials at Burichanj, Comilla

Appendix-K

Operational cost of rice transplanter for puddled and un-puddled transplanting

Table K1. Fixed cost calculation

Sl. No.	Items	Tk.
1	Purchase price (P) (Tk)	300000
2	Salvage value (S) (Tk), Where S is 10% of P	30000
3	Working life (L) (yr)	8
4	[1]Average annual use (Au) (hr/yr)	560
5	Annual depreciation, D=(P-S)/L	33750
6	Interest on investment, I=(P+S)/2*I, where rate of interest is 12%	18180
7	Tax, insurance, T=3% of P	9000
8	Total fixed cost (D+I+T) (Tk/yr)	60930
9	Total fixed cost (Tk/hr)	108.80

Table K2. Variable cost calculation

Sl. No.	Total variable cost	Puddle	Un-puddle
1	[2]Labour cost per hour (Tk/hr)	65	65
2	Fuel cost (Tk/hr)	63.75	52.7
3	Lubricant cost (Tk/hr) (lubricant cost is 3% of fuel const)	1.91	1.58
4	RPM/hr =3.5 % of purchase price	18.75	18.75
5	Total Variable cost (Tk/hr)	149.41	138.03
6	Total operating cost Tk/hr (Fixed cost+ Variable cost)	258.21	246.83
7	Field capacity of rice transplanter (ha/hr)	0.14	0.13
8	Time for transplanting (hr/ha)	7.14	7.69
9	Operating Cost for transplanting (Tk/ha)	1844	1898

Note:

1. Average annual use of rice transplanter in three rice season is considered 75 days where 15 days in Aus, 25 days in Aman and 30 days in Boro season. Considering 8 working hrs, Average annual use in hrs/year is 560.
2. Labor cost as operator, Tk/hr=37.5 and helper cost, Tk/hr=27.5. Total cost, Tk/hr=65.0 and Agril. Labor cost, Tk/hr=280.00
3. Fuel price (Octane), Tk/lit=85.00

Appendix-L
Photographic view of field trials activities during Boro/2013

Fig. L1. Seedling raining on polythene sheet

Fig. L2. Seedling cutting by metallic frame

Fig. L3. Field trials at Mithapukur, Rangpur

Fig. L4. Before machine operation, discussion with farmers

Fig. L5. Bed planting at Sadar, Rangpur

Fig. L6. Field trials at Habiganj

Appendix-M

a. 3-D drawing view of different components for strip tillage arrangement in riding type rice transplanter

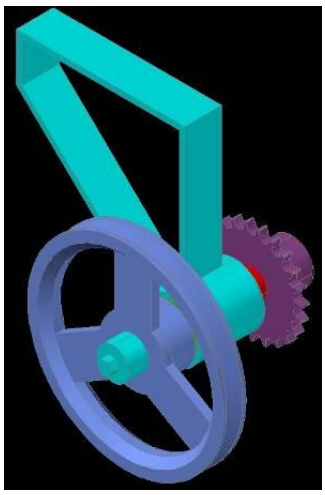


Fig. M_a1. Arrangement of 1st stage of power transmission

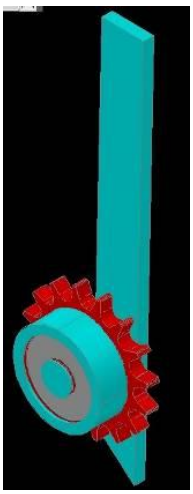


Fig. M_a2. Ideal sprocket

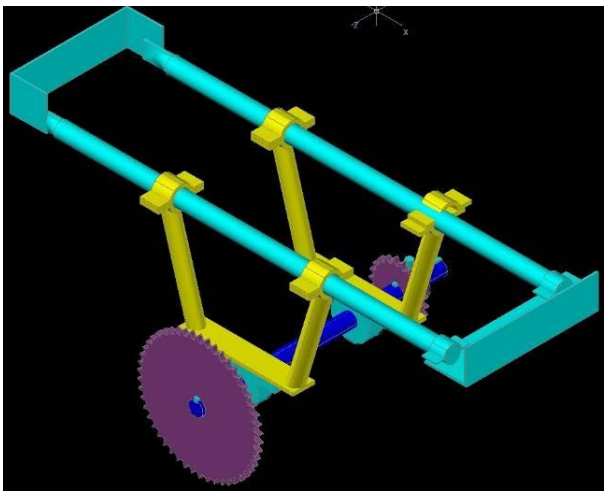


Fig. M_a3. Arrangement of 2nd stage of power transmission

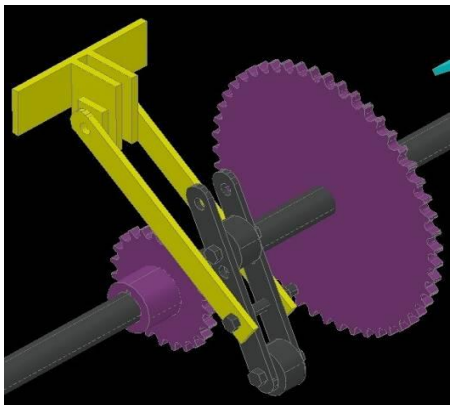


Fig. M_a4. Arrangement of 3rd stage of power transmission

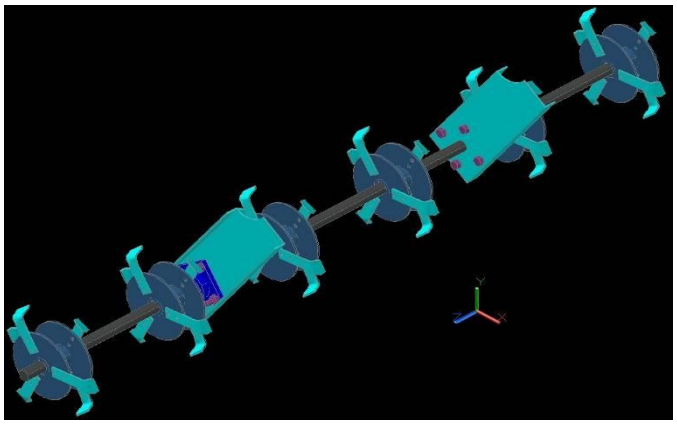


Fig. M_a5. Tine arrangement for strip tillage

b. Fabrication view as par drawing for strip tillage arrangement in riding type rice transplanter

Fig.M_b1. Power transmission arrangement form engine to 1st shaft

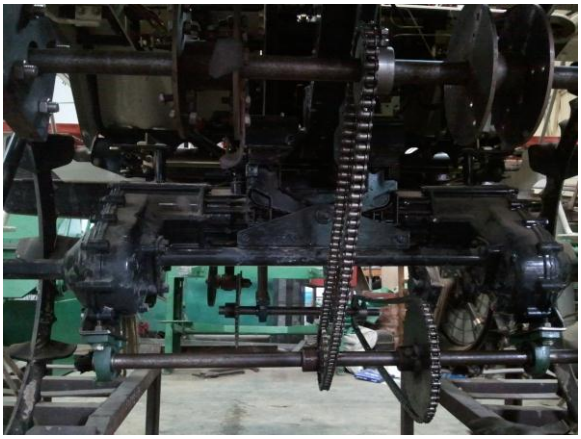


Fig.M_b2. Power transmission mechanism to different shaft

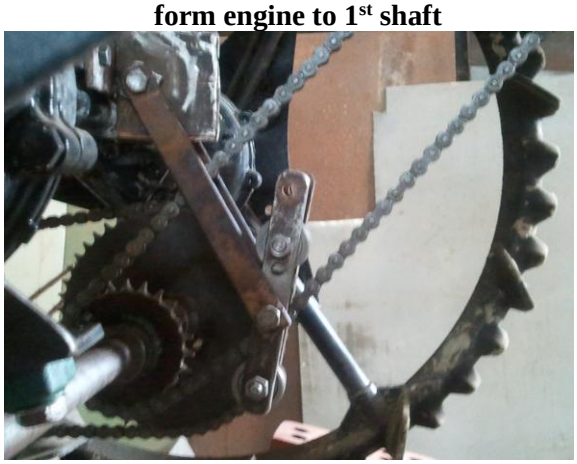


Fig.M_b3. Chain tension mechanism with rotary picker ups and down

Fig.M_b4. Strip tillage tine and shaft arrangement

Appendix-N

Preconditions of USG applicator and rice transplanter operation in the field

Through the research and farmers field trials of the USG applicator and rice transplanter, the following preconditions were drawn for efficient use of the technologies:

Precondition of USG Applicator operation

- Line transplanting maintain spacing 18 x 20, 20 x 20 and 22 x 20 is required
- Applicator should be operated by pushing force. Pulling create blockage of granule dispensing channel by mud.
- During field operation, minimum standing water (0.5-1.0cm) should be maintained for smooth operation.
- Standing water also have to be maintained in the field after rice transplanting till the date of USG application to keep the soil soft that helps the smooth operation by opening and closing the furrow properly.
- Applicator should be operated in the field before settling of the soil of the transplanted field
- Only 2/3 portion of the granule tank have to fill up by USG during field operation

Pre-requisites of mechanical transplanter operation

- The field should be leveled for better performance of rice transplanter and uniform crop establishment
- Settling time after preparing the field and water level in the field are the key factors for the success of the mechanical rice transplanting, after final leveling, allow the soil to settle for 12–24 hours.
- Sufficient bearing strength of soil is necessary to carry the machine and support the planted seedlings
- Avoid use of transplanter in low land ecologies where water remains stagnant
- Maintain only 1 cm water or saturated condition while transplanting
- Immediately after transplanting irrigation sometimes disturbs the seedlings
- Seedling should be uniform density and standard height.

Appendix-O
Large scale validation trials of USG applicator during Boro/2013

Table O1. Large scale validation trials of USG applicator in Godagari, Rajshahi during Boro/2013

Sl. No	Name of farmers address	Variety	Date of transplanting	Date of USG application	Area, decimal
1.	Md. Aminul Islam ,F/N: Md. Sajeman Ali Vill: Matherpur, Gudagari. Rajshahi	BRRI dhan28	20/02/2013	28/02/2013	33
2.	Md.Bojlur Rahaman, F/N: Lat. Hadimolla Vill:Vatuopara, Gudagari	BRRI dhan28	24/02/2013	05/03/2013	33
3.	Md. Sadek Ali, F/N: Md. Amjad Hossain Vill: Raninagar, Gudagari	BRRI dhan28	23/02/2013	02/03/2013	35
4.	Md. Fajlur Rhaman, F/N: lat. Ayub Ali Vill:Kashimpur, Baliaghata	BRRI dhan28	05/02/2013	14/02/2013	34
5.	Md.Habibur Rahaman , F/N: Haji Mohiuddin Vill: Kadipur, Machpara	BRRI dhan28	19/02/2013	26/02/2013	36
6.	Md. Nazmul Hossain ,F/N: Md Abdul Mannan Vill: Nabinagar, Gudagari	BRRI dhan28	11/02/2013	26/02/2013	34
7.	Md. Nayeb Ali, F/N: Afjal Shakh Vill:Chapal,Rajabari,Gudagari	BBRI dhan 50	10/02/2013	20/02/2013	28
8.	Md.Nazimuddin , F/N: Afjal Shakh Vill:Chapal,Rajabari,Gudagari	BRRI dhan28	28/02/2013	10/03/2013	32
9.	Md. Jamaluddin, F/N: Afjal Shakh Vill:Chapal,Rajabari,Gudagari	BRRI dhan28	02/03/201	11/03/2013	36
10.	Md. Alimuddin, F/N r:Muntaj Ali Vill: Gopalpur, Gudagari	BRRI dhan28	05/02/2013	14/03/2013	35
11.	Md.Shariful Islam, F/N:Md.Badiuzzaman Vill: Gopalpur, Gudagari	BRRI dhan28	10/02/2013	18/02/2013	33
12.	Md, Rayhan Ali, F/N: Md Baitul Sarkar Vill: Boghdamari, Gudagari	BRRI dhan28	17/02/2013	25/02/2013	34

Table O2. Large scale validation trials of USG applicator in Rangpur Sadar during Boro/2013

Sl.no	Name of farmers address	Variety	Date of transplanting	Date of USG application	Area, decimal
1.	Md. Shirajul Islam , F/N: Md. Sultan Vill: Ghagotpara, Rarngpur	BRRI dhan28	18/03/2013	22/03/2013	33
2.	Md. Abdur Razzak , F/N: Md. Shirajul Islam Vill: Ghagotpara, Rarngpur	BRRI dhan28	17/03/2013	21/03/2013	30
3.	Md. Mojnu Miah , F/N: Md. Ali Mohammad Vill: Ghagotpara, Rarngpur	BRRI dhan28	14/03/2013	20/03/2013	30
4.	Md. Rakunuzzaman, F/N: Md. Mustafizur	BRRI dhan28	12/03/2013	20/03/2013	20

	Vill: Ghagotpara, Rarngpur				
5.	Md. Oshman Ali, F/N: Md. Abu Talib Vill: Ghagotpara, Rarngpur	BRRI dhan28	17/03/2013	20/03/2013	20
6.	Md. Khorshed Ali, F/N: Md. Keyamot Ali Vill: Ghagotpara, Rarngpur	BRRI dhan28	19/03/2013	25/03/2013	25
7	Md. Alomgir Ali , F/N: Lat. Azom Ali Vill: Ghagotpara, Rarngpur	BRRI dhan28	19/03/2013	25/03/2013	20
8	Md. Atarul Islam, F/N: Lat. Tuzan Ali Vill: Ghagotpara, Rarngpur	BRRI dhan28	19/03/2013	25/03/2013	20

Table O3. Large scale validation trials of USG applicator in Burichang, Comilla during Boro/2013

Sl. no	Name of farmers address	Variety	Date of transplanting	Date of USG application	Area , decimal
1.	Md. Giash uddin Buiya , F/N:Lat.Ramizuddin Vill.Mohismara,Burichang	BRRI dhan28	25/02/2013	28/02/2013	16
2.	Md. Nurul Islam, F/N:Lat.Eiakub Ali Vill: Mohismara,Burichang	BRRI dhan29	24/02/2013	02/03/2013	14
3.	Md. Azad Miah, F/N: Abdul Mannan Vill: Mohismara,Burichang	BRRI dhan29	22/02/2013	02/03/2013	20
4.	Md. Nush Miah, F/N: Lat. Shiraj Miah Vill: Mohismara,Burichang	BRRI dhan29	20/02/2013	28/02/2013	16
5.	Md. Khairul Islam, F/N:Lat. Joynal Abiddin Vill: Mohismara,Burichang	BRRI dhan29	23/02/2013	01/03/2013	13
6.	Md. Rafikul Islam, F/N:Md. Eddresh Ali Vill: Mohismara,Burichang	BRRI dhan28	22/02/2013	02/03/2013	15
7.	Md. Hanif Miah, F/N:Lat. Abdul Munafh Vill: Mohismara,Burichang	BRRI dhan16	21/02/2013	28/02/2013	14
8.	Md. Shafik Miah, F/N:Lat. Abdul Aziz Vill: Mohismara,Burichang	BRRI dhan28	24/02/2013	01/02/2013	17
9.	Md. Salim Miah, F/N:Abdul Hakim Vill: Mohismara,Burichang	BRRI dhan29	21/02/2013	27/02/2013	15
10.	Md. Abul Kalam Azad, F/N: Lat. Mojol Hossian Vill: Mohismara,Burichang	BRRI dhan29	20/02/2013	28/02/2013	16
11.	Md. Mosharouf Hossian, F/N:Lat.Foyz Uddin Vill: Mohismara,Burichang	BRRI dhan29	19/02/2013	25/02/2013	18
12.	Md. Johir Uddin, F/N:Lat . Nurul Islam Vill: Mohismara,Burichang	BRRI dhan28	24/02/2013	03/03/2013	40
13.	Md. Khokon Miah, F/N: Lat. Sundor Ali Vill: Gazipur,Burichang	BRRI dhan16	23/02/2013	03/03/2013	16
14.	Md. Hasan Miah, F/N:Lat. Junab Ali	BRRI	28/02/2013	04/03/2013	15

	Vill:Gazipur, Burichang	dhan28			
15.	Md. Razaul Islam, F/N:Lat.Rahamot Ali Vill: Gazipur, Burichang	BRRI dhan29	21/02/2013	25/02/2013	16
16.	Md.Shah Alom , F/N:Lat.Hafejullah Vill: Gazipur, Burichang	BRRI dhan16	20/02/2013	24/02/2013	14
17.	Md. Nargis Akter, F/N: Kabir Hossain Vill: Gazipur, Burichang	BRRI dhan29	20/02/2013	27/02/2013	18
18.	Md. Abul Hossain, F/N:Lat. Hafiz Uddin Vill: Gazipur, Burichang	BRRI dhan29	20/02/2013	25/02/2013	15
19.	Md. Shah Alom , F/N:Md. Hari Miah Vill: Gazipur, Burichang	BRRI dhan28	21/02/2013	25/02/2013	16
20.	Md. Mizanur Rahaman , F/N:Lat. Fajler Rahaman Vill: Gazipur, Burichang	BRRI dhan29	20/02/2013	24/02/2013	12
21.	Md. Shamsul Haqe , F/N:Lat.Babru Miah Vill: Gazipur, Burichang	BRRI dhan28	20/02/2013	23/02/2013	15
22.	Md. Jamal Hossain , F/N:Md. Abdul Barak Vill: Kharatia, Burichang	BRRI dhan29	20/02/2013	26/02/2013	16
23.	Md. Abdul Kader, F/N:Md. Abdul Jalil Vill: Kharatia, Burichang	BRRI dhan16	21/02/2013	27/02/2013	17
24.	Md. Shirajul Islam, F/N: Lat. Chando Miah Vill:Mohismara Burichang	BRRI dhan28	20/02/2013	27/02/2013	16
25.	Md.Shah Alom , F/N: Lat. Sajot Miah Vill: Kharatia, Burichang	BRRI dhan29	19/02/2013	24/02/2013	18
26.	Md. Abdul Latif , F/N:Lat. Sajot Miah Vill: Kharatia, Burichang	BRRI dhan16	20/02/2013	16/02/2013	26

Table O4. Large scale validation trials of USG applicator in Purbodhala, Netrakona during Boro/2013

Sl. No.	Name of farmers address	Variety	Date of transplanting	Date of USG application	Area, decimal
1.	Md. Shahabuddin, F/N:Md. Shahed Ali Vill: Kishmot Baranga	BRRI dhan28	08/02/2013	18/02/2013	49
2.	Md. Giash Uddin , F/N:Md. Shahed Ali Vill: Kishmot Baranga	BRRI dhan28	06/02/2013	13/02/2013	33
3.	Md. Joshim Uddin, F/N:Md. Madon Ali Vill: Kishmot Baranga	BRRI dhan29	31/01/2013	09/02/213	34
4.	Md. Shamsul Haqe , F/N:Md.Jalal Uddin Vill: Kishmot Baranga	BRRI dhan29	30/01/2013	08/02/2013	33
5.	Md. Abul Kalam , F/N:Md.Jahor Ali Vill: Kishmot Baranga	BRRI dhan29	06/02/2013	14/02/2013	50
6.	Md.Shohidullah , F/N:Md Shariat Ali	BRRI dhan28	08/02/2013	14/02/2013	49

	Vill: Kishmot Baranga				
7.	Md.Habibur Ali , F/N:Md.Kasum Ali Vill: Kishmot Baranga	BRRI dhan28	06/02/2013	19/02/2013	48
8.	Md. Alamin , F/N:Lat. Abul Kalam Vill:Laukhai,Netrakona	BRRI dhan28	07/02/2013	14/02/2013	48
9.	Md. Helal Uddin, F/N: Nurul Uddin Vill:Badey Baranga	BRRI dhan29	10/02/2013	20/02/2013	33
10.	Md. Ekhlas Uddin, F/N:Md.Shohed Ali Vill: Kishmot Baranga	BRRI dhan29	11/02/2013	18/02/2013	33
11.	Md. Abdul Kader , F/N: Lat. Zamor Ali Vill: Kishmot Baranga	BRRI dhan29	08/02/2013	17/02/2013	35
12.	Md.Khairul Islam , F/N:Md. Abdur Rashid Vill: Kishmot Baranga	BRRI dhan29	30/01/2013	11/02/2013	32
13.	Md.Hazrat Ali , F/N:Lat.Wuahed Ali Vill: Kishmot Baranga	BRRI dhan29	01/02/2013	10/02/2013	47
14.	Md. Dulal Miah , F/N :Md. Shamsuddin Vill. Kishmot Baranga	BRRI dhan28	20/02/2013	28/02/2013	20
15.	Md. Shamsuddin, F/N:Shakh Faju Vill: Kishmot Baranga	BRRI dhan28	01/02/2013	11/02/2013	49
16.	Md. Dulal Mondal, F/N:Md.Matab Uddin Vill: Kishmot Baranga	BRRI dhan28	04/02/2013	16/02/2013	33
17.	Md. Mutaleb Miah , F/N:Md. Akshad Ali Vill: Ishubpur, Purbadhala	BRRI dhan28	06/02/2013	14/02/2013	33
18.	Md. Haresh Uddin, F/N:Lat. Aran Ali Vill: Hat Baranga, Purbadhala	BRRI dhan29	28/01/2013	05/02/2013	34
19.	Md. Abdur Rashid , F/N:Md.Kasum Ali Vill: Hat Baranga, Purbadhala	BRRI dhan28	05/02/2013	14/02/2013	33
20.	Md.Akshad Ali, F/N:Lat.Fazar Ali Vill: Ishubpur, Purbadhala	BRRI dhan28	04/02/2013	15/02/2013	33
21.	Md. Ruhul Amin , F/N:Mohammad Ali Vill: Ishubpur, Purbadhala	BRRI dhan28	31/01/2013	12/02/2013	35
22.	Md. Abdus Sattar ,F/N:Md. Ismile Akando Vill: Jalshuka	BRRI dhan28	30/01/2013	10/02/2013	33
23.	Md. Mahidi Hasan, F/N:Md. Abdus Sattar Vill: Kishmot Baranga	BRRI dhan28	30/01/2013	10/02/2013	33
24.	Md.Abdul Zalil , F/N:Lat. Anir Uddin Vill: Kishmot Baranga	BRRI dhan28	04/02/2013	11/02/2013	20
25.	Md.Jaynal Abbedin , F/N:Lat. Riaz Uddin Vill: Ishubpur, Purbadhala	BRRI dhan28	07/02/2013	15/02/2013	25

Table O5. Large scale validation trials of USG applicator in Challisha, Sadar Netrakona during Boro/2013

Sl. No.	Name of farmers address	Variety	Date of transplanting	Date of USG application	Area, decimal
1.	Md: Jafarullah, F/N:Md. Azizul Islam Vill: Rajendrapur,Netrakona	BRRI dhan29	12/02/2013	20/02/2013	33
2.	Md: Faruk Miah, F/N:Md.Monjul Vill: Rajendrapur,Netrakona	BRRI dhan29	05/02/2013	18/02/2013	33
3.	Md: Saidul Islam , F/N:Md. Samsul Huqe Vill: Rajendrapur,Netrakona	BRRI dhan29	04/02/2013	18/02/2013	33
4.	Md: Abul Islam , F/N:Md.Samed Ali Vill: Rajendrapur,Netrakona	BRRI dhan29	02/02/2013	18/02/2013	33
5.	Md: Nurul Islam, F/N:Md.Samed Ali Vill: Rajendrapur,Netrakona	BRRI dhan29	02/02/2013	17/02/2013	33
6.	Md: Ahammad Ali , F/N:Md. Suruj Ali Vill: Rajendrapur,Netrakona	BRRI dhan29	05/02/2013	19/02/2013	33
7.	Md: Chan Miah, F/N:Md.Suruj Ali Vill: Rajendrapur,Netrakona	BRRI dhan28	04/02/2013	19/02/2013	33
8.	Md: Hanif Miah , F/N:Md.Khurshed Ali Vill: Rajendrapur,Netrakona	BRRI dhan29	10/02/2013	20/02/2013	33
9.	Md: Salatu Miah , F/N:Md. Tanir Uddin Vill: Rajendrapur,Netrakona	BRRI dhan29	04/02/2013	20/02/2013	33
10.	Md: Abul Miah , F/N:Md.Tanir Uddin Vill: Rajendrapur,Netrakona	BRRI dhan29	04/02/2013	20/02/2013	33
11.	Md: Hellal Miah, F/N:Md. Iddrish Ali Vill: Challisha, Netrakona	BRRI dhan28	01/02/2013	19/02/2013	33
12.	Md: Abdul Hamid Miah , F/N:Md.Abdul Khalek Vill: Challisha, Netrakona	BRRI dhan29	08/02/2013	19/02/2013	33
13.	Md: Motahar Hossain, F/N:Md. Nur Hossain Vill: Rajendrapur,Netrakona	BRRI dhan28	11/02/2013	20/02/2013	33
14.	Md: Mustakin , F/N:Md. Ear Hossain Vill: Rajendrapur,Netrakona	BRRI dhan28	04/02/2013	19/02/2013	33
15.	Md: Wazed Ali, F/N:Md. Zalal Uddin Vill: Challisha , Netrakona	BRRI dhan29	04/02/2013	19/02/2013	33
16.	Md: Shajan Ali, F/N:Md.Nur Hossain Vill: Rajendrapur,Netrakona	BRRI dhan28	04/02/2013	19/02/2013	33
17.	Md: Kamal Uddin , F/N:Md. Jahur Uddin Vill: Rajendrapur,Netrakona	BRRI dhan29	05/02/2013	20/02/2013	33
18.	Md: Emdadul Huqe, F/N:Md.Abdul Khalek Vill: Nurulia, Netrakona	BRRI dhan29	04/02/2013	20/02/2013	33
19.	Md:Abdul Kader , F/N:Md.Nouab Ali Vill: Challisha, Netrakona	BRRI dhan29	03/02/2013	18/02/2013	33

20.	Md: Abdul Latif , F/N:Md. Nouab Ali Vill: Challisha, Netrakona	BRRI dhan29	07/02/2013	19/02/2013	33
21.	Md:Yeakub Ali , F/N:Md. Hurmuj Ali Vill: Challisha, Netrakona	BRRI dhan29	07/02/2013	19/02/2013	33
22.	Md:Farid Uddin , F/N:Md. Abdul Zabbar Vill: Challisha, Netrakona	BRRI dhan29	05/02/2013	19/02/2013	33
23.	Md: Kamal Hossain, F/N:Md.Nurul Miah Vill: Challisha, Netrakona	BRRI dhan29	10/02/2013	20/02/2013	33
24.	Md: Mafij Uddin , F/N:Md.Taley Hossain Vill: Challisha, Netrakona	BRRI dhan29	05/02/2013	18/02/2013	33
25.	Md: Salim Hossain , F/N:Md. Naib Uddin Vill: Nurulia, Netrakona	BRRI dhan28	07/02/2013	17/02/2013	33

Table O6. Large scale validation trials of USG applicator in Laksam, Comilla during Boro/2013

Sl. no	Name of farmers address	Variety	Date of transplanting	Date of USG application	Area, decimal
1.	Md: Imam Hossain, F/N: Lat.Rahamot Ali Vill: Laksam, Comilla	BR 16	07/02/2013	12/02/2013	33
2.	Md: Momin Miah, F/N: Md.Abdul Mojid Vill: Laksam, Comilla	BR 16	05/02/2013	10/02/2013	36
3.	Md: Abdul Rashid, F/N: Md. Haji Nouab Ali Vill: Laksam, Comilla	BR 16	10/02/2013	14/02/2013	30
4.	Md: Samsul Huqe , F/N: Md. Haji Nouab Ali Vill: Laksam, Comilla	BRRI dhan29	11/02/2013	15/02/2013	30
5.	Md: Mahabubul Alom , F/N: Lat. Abdul Gafur Vill: Laksam, Comilla	BRRI dhan29	10/02/2013	16/02/2013	24
6.	Md: Ahashan Ullah, F/N: Lat. Abdus Salam Vill: Laksam, Comilla	BRRI dhan50	09/02/2013	17/02/2013	30
7.	Md: Shajan, F/N: Lat Nouab Ali Vill: Laksam, Comilla	BRRI dhan29	15/02/2013	20/02/2013	33
8.	Md: Razzob Ali, F/N: Md. Ushuf Ali Vill: Laksam, Comilla	BRRI dhan29	04/02/2013	08/02/2013	42
9.	Md: Abdul Karim , F/N: Md.Samsul Huqe Vill: Laksam, Comilla	BRRI dhan29	14/02/2013	17/02/2013	33
10.	Md: Anwar Hossain, F/N: Md. Ayub Ali Vill: Laksam, Comilla	BRRI dhan28	14/02/2013	18/02/2013	24
11.	Md: Jahirul Islam, F/N:Lat. Abdul Aziz Vill: Laksam, Comilla	NAFKO 108	10/02/2013	17/02/2013	30
12.	Md: Alomgir Hossain , F/N: Md. Ruhul Amin	BRRI dhan29	11/02/2013	15/02/2013	36

	Vill: Laksam, Comilla				
13.	Md: Hossain , F/N:Lat. Ayub Ali Vill: Laksam, Comilla	BRRI dhan28	15/02/2013	18/02/2013	30
14.	Md: Bellal Hossain, F/N: Md.Ranjosh Ali Vill: Laksam, Comilla	A C I-1	15/02/2013	19/02/2013	20
15.	Md: Mojibul Huqe , F/N: Md. Rustom Ali Vill: Laksam, Comilla	HIRA-5	04/02/2013	09/02/2013	30
16.	Md: kamal Hossain, F/N: Md. Nurujjaman Vill: Laksam, Comilla	BRRI dhan28	17/02/2013	20/02/2013	33
17.	Md:Abdul Karim , F/N: Md.Abdul Motin Vill: Laksam, Comilla	A C I-2	09/02/2013	17/02/2013	24
18.	Md: Eshahak Miah , F/N: Lat. Ismile Vill: Laksam, Comilla	BRRI dhan29	05/02/2013	13/02/2013	30

Table O7. Large scale validation trials of USG applicator in Sadar, Hobiganj during Boro/2013

Sl. no	Name of farmers address	Variety	Date of transplanting	Date of USG application	Area, decimal
1.	Md: Akkas Ali , F/N:Md.Suruj Ali Vill:Gurasunda, Hobiganj	BRRI dhan28	25/01/2013	01/02/2013	33
2.	Md: Ushuf Ali, F/N:Md.Entaj Ali Vill: Gurasunda, Hobiganj	BRRI dhan29	24/01/2013	01/02/2013	33
3.	Md: Mongla Miah, F/N:Md. Sattor Miah Vill: Gurasunda, Hobiganj	BRRI dhan29	23/01/2013	31/02/2013	33
4.	Md: Alauddin Miah, F/N:Md. Ali Hossain Vill: Gurasunda, Hobiganj	BRRI dhan29	28/01/2013	06/02/2013	33
5.	Md: Rasel Hossain, F/N:Md. Abul Khaer Vill: Gurasunda, Hobiganj	BRRI dhan29	28/01/2013	06/02/2013	33
6.	Md: Ahed Miah, F/N:Md. Ali Samad Vill: Gurasunda, Hobiganj	BRRI dhan29	29/01/2013	10/02/2013	33
7.	Md: Akbar Miah, F/N:Md. Lal Miah Vill: Gurasunda, Hobiganj	BRRI dhan29	29/01/2013	07/02/2013	33
8.	Md: Abdul Motin, F/N:Md. Abdul Zabber Vill:Surabui, Hobiganj	BRRI dhan29	30/01/2013	09/02/2013	33
9.	Md: Muttalib Miah, F/N:Md. Abdul Zabber Vill: Surabui, Hobiganj	BRRI dhan29	24/01/2013	01/02/2013	33
10.	Md: Edon Miah, F/N:Md. Ving Raj Miah Vill: Surabui, Hobiganj	BRRI dhan29	02/01/2013	12/02/2013	33
11.	Md: Habil Miah, F/N:Md. Zitu Miah Vill: Surabui, Hobiganj	BRRI dhan29	02/01/2013	11/02/2013	33
12.	Md: Shohel Miah, F/N:Md. Zitu Miah Vill: Surabui, Hobiganj	BRRI dhan29	04/01/2013	13/02/2013	33
13.	Md: Dulal Miah, F/N:Md. Abdul Sattar Vill: Surabui, Hobiganj	BRRI dhan29	30/01/2013	06/02/2013	33

14.	Md: Sujon Miah, F/N:Md.Akkas Miah Vill: Gurasunda, Hobiganj	BRRI dhan28	03/02/2013	10/02/2013	33
15.	Md: Sumon Miah, F/N:Md. Anwar Ali Vill:Suciura,Hobiganj	BRRI dhan29	27/01/2013	04/02/2013	33
16.	Md: Sanjoy Miah, F/N:Md.Karom Ali Vill: Suciura,Hobiganj	BRRI dhan29	28/01/2013	06/02/2013	33
17.	Md: Suno Miah, F/N:Md. Abul Hossain Vill: Alipur, Hobiganj	BRRI dhan29	31/01/2013	10/02/2013	33
18.	Md: Rubel Miah, F/N:Md. Rafik Miah Vill: Alipur, Hobiganj	BRRI dhan29	02/02/2013	11/02/2013	33
19.	Md: Junahed Miah, F/N:Md. Aksed Miah Vill: Suciura,Hobiganj	BRRI dhan29	04/02/2013	12/02/2013	33
20.	Md: Abu Taher, F/N:Md. Abdus Sattar Vill:Eshlotpur, Hobiganj	BRRI dhan29	21/01/2013	02/02/2013	33
21.	Md: Farhad Miah, F/N:Md. Abu Miah Vill: Eshlotpur, Hobiganj	BRRI dhan29	21/01/2013	30/01/2013	33
22.	Bakul Dash, F/N: Baloram Dash Vill: Surabui, Hobiganj	BRRI dhan29	25/01/2013	02/02/2013	33
23.	Md: Mokhles Miah, F/N:Md.Shiraj Miah Vill: Surabui, Hobiganj	BRRI dhan29	25/01/2013	03/02/2013	33
24.	Md:Liton Miah, F/N:Md. Najir Miah Vill: Baghobpur,Hobiganj	BRRI dhan29	26/01/2013	02/02/2013	33
25.	Md: Farid miah, F/N:Md.Lal Miah Vill: Surabui, Hobiganj	BRRI dhan29	26/01/2013	03/02/2013	33
26.	Md: Palash Miah, F/N:Md. Abdus Sattar Vill: Surabui, Hobiganj	BRRI dhan29	29/01/2013	07/02/2013	33

Table O8. Large scale validation trials of USG applicator in Baniachang, Hobiganj during Boro/2013

Sl. no	Name of farmers address	Variety	Date of transplanting	Date of USG application	Area, decimal
1.	Md: Abdul Hamid Khan, F/N:Md. Abdus Salam Vill: Murkhani,Baniachang	HIRA dhan	15/01/2013	22/01/2013	28
2.	Md: Azizur Rahaman, F/N:Lat. Kuddus Ullah Vill: ProthomRakh, Baniachang	HIRA dhan	10/01/2013	18/01/2013	50
3.	Md: Mohoram Ali, F/N: Din Shakh Vill: Mirkhani, Baniachang	BRRI dhan29	10/01/2013	18/01/2013	25
4.	Md: Abdus Salam, F/N:Lat. Abdus Samed Vill: Mirkhani, Baniachang	LALTEER Dhan	10/01/2013	18/01/2013	25
5.	Md: Jahid Ali, F/N:Lat. Abu Syed Vill: Choturonger, Baniachang	HIRA-2 Dhan	10/01/2013	18/01/2013	50
6.	Md: Nabey Rah. Khan, F/N:Md. Fajlur	BRRI	10/01/2013	18/01/2013	20

	Rahaman Vill: Nandipara, Baniachang	dhan29			
7.	Md: Abdul Karim, F/N:Md. Taiub Ali Vill:Dattopara, Baniachang	CHOMOK Dhan	10/01/2013	18/01/2013	25
8.	Md: Solaman ali Khan, F/N: Suruj Ali Khan Vill: Dattopara, Baniachang	BRRI dhan29	10/01/2013	18/01/2013	25
9.	Jagodish Chandro Ghosh, F/N:Lat. Mitendro Ghosh Vill: Dattopara, Baniachang	BRRI dhan29	10/01/2013	18/01/2013	50
10.	Arobindu Dash,F/N: Umel Dash Vill:Canpur, Baniachang	BRRI dhan29	10/01/2013	18/01/2013	50
11.	Md: Ful Miah, F/N:Md. Abdul Karim Vill: Nandipara, Baniachang	HIRA-2 dhan	10/01/2013	18/01/2013	25
12.	Md:Abdul zalil, F/N: Lat Abdur Rahim Vill: Nandipara, Baniachang	HIRA-2 Dhan	10/01/2013	18/01/2013	25
13.	Md: Azad Miah, F/N:Lat.Younus Ullah Vill: Nandipara, Baniachang	BRRI dhan29	10/01/2013	18/01/2013	50
14.	Md: Bajlu Miah, F/N:Lat. Mahoram Ali Vill: ProthomRakh, Baniachang	BRRI dhan29	01/01/2013	06/01/2013	25
15.	Md: Lal Miah, F/N:Md. Karim Miah Vill: Nandipara, Baniachang	BRRI dhan29	15/01/2013	20/01/2013	50
16.	Md: Samsu Miah, F/N:Md.Abdul Halim Vill: Darga mahollah	HIRA-2 dhan	15/01/2013	20/01/2013	50
17.	Md: Salamot Ali, F/N:Md. Lal Kha Vill: Dattopara, Baniachang	ACI-1Dhan	15/01/2013	20/01/2013	25
18.	Md:Abdul Rahim, F/N:Md. Abdul Aziz Vill: Dattopara, Baniachang	BRRI dhan29	15/01/2013	20/01/2013	20
19.	Md:Hellal Miah, F/N:Md. Saddor Ullah Vill: Choturonger, Baniachang	HIRA-2 Dhan	15/01/2013	20/01/2013	25
20	Md:Darbesh Miah, F/N:Md. Churuk Miah Vill: Topkhana , Baniachang	BRRI dhan29	15/01/2013	20/01/2013	25
21.	Md:Mamudur Rah. Khan, F/N:Lat Habibur Rahaman, Vill: Dattopara, Baniachang	BRRI dhan29	15/01/2013	20/01/2013	20
22.	Md: Eddrish Ali, F/N:Md.Michik Ali Vill: Dattopara, Baniachang	LALTEER dhan	15/01/2013	20/01/2013	25
23.	Md: Zit Miah, F/N:Md.Abdul Hamim Vill: Darga Mahollah	HIRA-2 Dhan	15/01/2013	20/01/2013	20
24.	Md: Dulu Miah, F/N:Md. Eshahak Ali Vill: Kamal Khani	BRRI dhan29	15/01/2013	20/01/2013	25
25.	Md: Zyed Ali, F/N:Md.Moyduzzaman Vill: Nandipara, Baniachang	BRRI dhan29	15/01/2013	20/01/2013	50
26.	Md: Member Ali, F/N:Md.Arob Ali Vill: Nandipara, Baniachang	BRRI dhan29	15/01/2013	20/01/2013	25

Table O9. Large scale validation trials of USG applicator in Motmaliat , Kumerkhali, Kushtia during Boro/2013

SL.no	Name of farmers address	Variety	Date of transplanting	Date of USG application	Area, decimal
1.	Md: Shab Uddin, F/N:Lat. Attab Uddin Vill: Tarapur,Kumerkhali	SL-8H	28/01/2013 02/02/2013	07/02/2013 09/02/2013	1.0 33
2.	Md: Abdul Kader, F/N:Md. Jabed Ali Vill: Tarapur,Kumerkhali	SL-8H	03/02/2013	10/02/2013	50
3.	Md: Nurul Islam, F/N:Md. Karom Ali Vill: Tarapur,Kumerkhali	BRRI dhan29	04/02/2013 10/02/2013	12/02/2013 19/02/2013	87 30
4.	Md: Babul Hossain, F/N:Md. Abu Bakkar Ali Vill: Tarapur,Kumerkhali	SL-8H	09/02/2013	17/02/2013	52
5.	Md: Sunaullah, F/N:Lat. Eiab Ali Vill: Tarapur,Kumerkhali	SL-8H	08/02/2013	18/02/2013	22
6.	Md: Habibur Rahaman, F/N:Lat. Khabir Ali Vill: Tarapur,Kumerkhali	SL-8H	10/02/2013	18/02/2013	35
7.	Md: Shafi Uddin, F/N:Md. Aftab Ali Vill: Tarapur,Kumerkhali	SL-8H	09/02/2013	18/02/2013	50
8.	Md: Refaul Karim, F/N:Lat. Ebadat Ali Vill: Tarapur,Kumerkhali	BRRI dhan29	11/02/2013	19/02/2013	66
9.	Md: Abdul Karim, F/N: Lat.Zoki Pramanik Vill: Tarapur,Kumerkhali	BRRI dhan29	12/02/2013	19/02/2013	20
10.	Md:khalilur Rahaman, F/N:Lat Abdul Jalil Vill: Tarapur,Kumerkhali	BRRI dhan29	13/02/2013	19/02/2013	35
11.	Md:Shajahan Ali, F/N:Md.Moshlem Ali Vill: Tarapur,Kumerkhali	BRRI dhan29	09/02/2013	19/02/2013	22
12.	Md: Fatin Uddin, F/N:Lat Ismil Uddin Vill: Tarapur,Kumerkhali	BRRI dhan29	11/02/2013	19/02/2013	12
13.	Md: Ayub Ali, F/N:Lat. Mansur Ali Vill: Tarapur,Kumerkhali	SL-8H	08/02/2013	19/02/2013	35
14.	Md: Yousuf Ali, F/N:Md.Rajob Ali Vill: Tarapur,Kumerkhali	SL-8H	12/02/2013	19/02/2013	58
15.	Md: Nizam Ali, F/N:Lat. Aftab Uddin Vill: Tarapur,Kumerkhali	SL-8H	11/02/2013	20/02/2013	33
16.	Md: Amir Hamza, F/N:Md. Kutub Uddin Vill: Tarapur,Kumerkhali	SL-8H	09/02/2013	20/02/2013	66
17.	Md: Habibullah, F/N:Md. Nur Mohammad Vill: Tarapur,Kumerkhali	SL-8H	12/02/2013	20/02/2013	22
18.	Md: Abdur Razzak, F/N:Md. Amir Hossain	SL-8H	13/02/2013	20/02/2013	33

	Vill: Tarapur,Kumerkhali				
19.	Md:Bahir Uddin, F/N:Md.Kamat Uddin Vill: Tarapur,Kumerkhali	SL-8H	14/02/2013	21/02/2013	33
20.	Md: Abdur Rahim, F/N: Lat.Zoki Pramanik Vill: Tarapur,Kumerkhali	BRRI dhan29	12/02/2013	21/02/2013	33
21.	Md: Abdul Gaffar, F/N:Md. Sadar Uddin Vill: Tarapur,Kumerkhali	BRRI dhan29	11/02/2013	21/02/2013	34
22.	Md: Abu Bakkar, F/N:Md. Sadar Uddin Vill: Tarapur,Kumerkhali	BRRI dhan29	09/02/2013	21/02/2013	66
23.	Md:Ahammad Ali, F/N:Lat. Ismil Hossain Vill: Tarapur,Kumerkhali	BRRI dhan29	18/02/2013	21/02/2013	33
24.	Md: Ataur Rahaman, F/N:Lat Abdul Jalil Vill: Tarapur,Kumerkhali	BRRI dhan29	1/02/2013	21/02/2013	33
25.	Md: Momin Shakh, F/N:Lat.Ukil Uddin Vill: Khayerpur, Kumer Khali	SL-8H	07/02/2013	14/02/2013	32
26.	Md: Alauddin, F/N: Lat.Ukil Uddin Vill: Khayerpur, Kumer Khali	SL-8H	06/02/2013	15/02/2013	20
27.	Md:Abdul Khalek, F/N:Md.Amir Hossain Vill: Khayerpur, Kumer Khali	SL-8H	02/02/2013	13/02/2013	33
28.	Md: Riaz Uddin, F/N:Md. Amir Hossain Vill: Hamimpur, Kumer Khali	SL-8H	04/02/2013	13/02/2013	16
29.	Md: Alom Hossian, F/N:Md.Abdul Zabbar Vill: Motmaliat, Kumer Khali	BRRI dhan29	02/02/2013	08/02/2013	70
30.	Md:Rabiul Islam, F/N:Md. Abdul Zabbar Vill: Motmaliat, Kumer Khali	BRRI dhan29	12/02/2013	17/02/2013	40
31.	Md: Babul Miah, F/N:Md.Abu Bakkar Vill: Tarapur, Kumer Khali	BRRI dhan29	10/02/2013	17/02/2013	26
32.	Nemycandra Bishaws, F/N:Lat Kalicaron Bishaws Vill: Batikamara, Kumer Khali	BRRI dhan29	14/02/2013	24/02/2013	50
33.	Md:Ator ali, F/N:Lat Jaynal Shakh Vill: Khayerpur, Kumer Khali	BRRI dhan29	13/02/2013	13/02/2013	33
34.	Md: Jakaria, F/N:Md. Ziaul Huqe Vill: Batikamara, Kumer Khali	BRRI dhan29	10/02/2013	25/02/2013	33
35.	Md: Raju Shakh, F/N:Md.Moshlem Ali Vill: Khayerpur, Kumer Khali	BRRI dhan29	09/02/2013	18/02/2013	66
36.	Md:Rakunuzzaman, F/N:Lat. Jala Uddin Vill: Batikamara, Kumer Khali	BRRI dhan29	05/02/2013	10/02/2013	45
37.	Md: Abdul Khalek, F/N: Lat. Jala Uddin	BRRI dhan29	05/02/2013	13/02/2013	33

	Vill: Batikamara, Kumer Khali				
38.	Md:Nur Islam, F/N: Lat. Jala Uddin Vill: Batikamara, Kumer Khali	BRRI dhan29	04/02/2013	11/02/2013	45
39.	Md: Alif Hossain, F/N: Lat. Jala Uddin Vill: Batikamara, Kumer Khali	BRRI dhan29	05/02/2013	11/02/2013	45
40.	Md: Mokam Hassain, F/N:Lat. Abdul HAkim Vill: Khayerpur, Kumer Khali	BRRI dhan29	15/02/2013	23/02/2013	66
41.	Md:Abdul Muttlab, F/N: Lat. Fazal Shakh Vill: Khayerpur, Kumer Khali	BRRI dhan29	17/02/2013	25/02/2013	33
42.	Md:Abdullah, F/N:Lat Abdul Hakim Vill: Khayerpur, Kumer Khali	BRRI dhan29	17/02/2013	24/02/2013	33
43.	Md:Ali Azam, F/N:Ukil Uddin Vill: Khayerpur, Kumer Khali	BRRI dhan29	16/02/2013	23/02/2013	35
44.	Md:Ashadul Islam, F/N:Md.Moshlem Uddin Vill: Khayerpur, Kumer Khali	SL-8H	06/02/2013	16/02/2013	33
45.	Md: Amirul Islam, F/N:Md. Ukil Uddin Vill: Khayerpur, Kumer Khali	SL-8H	02/02/2013	12/02/2013	36
46.	Md: Afeel Uddin, F/N:Lat.Shafij Uddin Vill: Khayerpur, Kumer Khali	SL-8H	05/02/2013	13/02/2013	33
47.	Md: Afeel Uddin, F/N:Lat. Ukil Uddin Vill: Khayerpur, Kumer Khali	SL-8H	04/02/2013	13/02/2013	36
48.	Md: Mojnu Shakh, F/N: Lat. Ukil Uddin Vill: Khayerpur, Kumer Khali	SL-8H	03/02/2013	14/02/2013	36
49.	Md: Saiful Islam, F/N:Md. Moshlem Uddin Vill: Khayerpur, Kumer Khali	SL-8H	06/02/2013	13/02/2013	08
50.	Md:Abdul Rashid, F/N:Md. Abdul Kader Vill: Khayerpur, Kumer Khali	SL-8H	01/02/2013	16/02/2013	50

Table O10. Large scale validation trials of USG applicator in Sadar Kushtia during Boro/2013

Sl. no	Name of farmers address	Variety	Date of transplanting	Date of USG application	Area, decimal
1.	Md. Atiar Rahaman, Vill: Baria, Kushtia	BRRI dhan28	05/02/2013	13/02/2013	33
2.	Md.Nur Islam, Vill: Baria, Kushtia	BRRI dhan50	05/02/2013	14/02/2013	25
3.	Md.Rustom Ali, Vill: Baria, Kushtia	BRRI dhan50	05/02/2013	15/02/2013	22
4.	Md. Abdur Rahim, Vill: Baria, Kushtia	BRRI dhan28	07/02/2013	15/02/2013	33
5.	Md.Saroar Malitha, Vill: Baria, Kushtia	BRRI dhan26	10/02/2013	19/02/2013	44

6.	Md.Abdul Khalek, Vill: Baria, Kushtia	BRRI dhan28	11/02/2013	21/02/2013	20
7.	Md.Oukil Miah, Vill: Baria, Kushtia	BRRI dhan28	11/02/2013	22/02/2013	21
8.	Md.Jhadu Mondal, Vill: Baria, Kushtia	BRRI dhan28	12/02/2013	22/02/2013	18
9.	Md.Ashadul , Vill: Baria, Kushtia	BRRI dhan28	10/02/2013	22/02/2013	20
10	Md. Kushar Shakh, Vill: Baria, Kushtia	BRRI dhan28	12/02/2013	21/02/2013	25
11.	Md.Azad Miah, Vill: Baria, Kushtia	BRRI dhan28	14/02/2013	21/02/2013	33
12.	Md.Sapon Shakh, Vill: Baria, Kushtia	BRRI dhan28	14/02/2013	21/02/2013	36
13	Md. Abdur Rashid, Vill: Baria, Kushtia	BRRI dhan28	14/02/2013	21/02/2013	38
14.	Md.Bador Uddin, Vill: Baria, Kushtia	BRRI dhan28	10/02/2013	22/02/2013	38
15.	Md. Abul Kashem, Vill: Baria, Kushtia	BRRI dhan28	11/02/2013	22/02/2013	32
16.	Md.Asgar Mondal, Vill: Baria, Kushtia	BRRI dhan28	08/02/2013	22/02/2013	35
17.	Md. Mojam Mondal, Vill: Baria, Kushtia	BRRI dhan28	12/02/2013	21/02/2013	32
18.	Md. Khairul Islam, Vill: Baria, Kushtia	BRRI dhan28	08/02/2013	19/02/2013	36
19.	Md. Nur mohammad Shakh, Vill: Baria, Kushtia	BRRI dhan28	15/02/2013	22/02/2013	32
20.	Md.Atiar Mondal, Vill: Baria, Kushtia	BRRI dhan28	14/02/2013	21/02/2013	38
21.	Md. Riaz Uddin, Vill: Baria, Kushtia	BRRI dhan28	12/02/2013	23/02/2013	50
22.	Md. Mafij Uddin, Vill: Baria, Kushtia	BRRI dhan28	14/02/2013	23/02/2013	42
23.	Md.Afil Uddin, Vill: Baria, Kushtia	BRRI dhan28	15/02/2013	23/02/2013	37
24.	Md.Shajahan, Vill: Baria, Kushtia	BRRI dhan28	12/02/2013	20/02/2013	35
25.	Md.Azibar, Vill: Baria, Kushtia	BRRI dhan28	15/02/2013	20/02/2013	22
26.	Md. Syedul, Vill: Baria, Kushtia	BRRI dhan28	12/02/2013	18/02/2013	30

Table O11. Large scale validation trials of USG applicator in Paba, Rajshjahi during Boro/2013

Sl. no	Name of farmers address	Variety	Date of transplanting	Date of USG application	Area, decimal
1.	Md. Kurban ali, Vill:Kashba, Rajshahi	BRRI dhan28	12/02/2013	22/02/2013	33
2.	Md. Masud Rana, Vill: Alimgonj, Rajshahi	BRRI dhan28	15/02/2013	24/02/2013	33
3.	Md. Gulam Nabe, Vill: natun Kashba, Rajshahi	BRRI dhan28	15/02/2013	24/02/2013	33

4.	Md.Ramjan Ali, Vill: Haldibona, Rajshahi	BRRI dhan28	15/02/2013	24/02/2013	33
5.	Md.Samsul Huqe, Vill: Alimgonj, Rajshahi	BRRI dhan28	19/02/2013	20/02/2013	33
6.	Md. Zinnar Rah Ali, Vill: natun Kashba, Rajshahi	BRRI dhan28	12/02/2013	20/02/2013	16
7.	Md. Nur Mohammad, Vill: Alimgonj, Rajshahi	BRRI dhan28	10/02/2013	20/02/2013	17
8.	Md. Tota Miah, Vill: Alimgonj, Rajshahi	BRRI dhan28	18/02/2013	21/02/2013	16
9.	Md.Abul Hossain, Vill:Berpara, Rajshahi	BRRI dhan28	17/02/2013	23/02/2013	17
10.	Md.Azizul Huqe, Vill: Alimgonj, Rajshahi	BRRI dhan28	19/02/2013	20/02/2013	33
11.	Md. Shohidul Islam, Vill: natun Kashba, Rajshahi	BRRI dhan28	13/02/2013	21/02/2013	17
12.	Md. Saidur Islam, Vill: Alimgonj, Rajshahi	BRRI dhan28	20/02/2013	24/02/2013	16
13.	Md. Fazlu Miah, Vill: natun Kashba, Rajshahi	BRRI dhan28	20/02/2013	52/02/2013	17
14.	Md. Shajahan Ali, Vill: Alimgonj, Rajshahi	BRRI dhan28	21/02/2013	25/02/2013	16
15.	Md. Nashim Uddin, Vill: Alimgonj, Rajshahi	BRRI dhan28	22/02/2013	26/02/2013	17
16.	Md. Badsha Hossain, Vill: Alimgonj, Rajshahi	BRRI dhan28	22/02/2013	25/02/2013	16
17.	Md. Tarikul Islam, Vill: Alimgonj, Rajshahi	BRRI dhan28	17/02/2013	22/02/2013	16
18.	Md.Farid Ali, Vill: Alimgonj, Rajshahi	BRRI dhan28	19/02/2013	22/02/2013	18

Table O12. Large scale validation trials of USG applicator in Mithapukur, Rangpur during Boro/2013

SL.no	Name of farmers address	Variety	Date of transplanting	Date of USG application	Area, decimal
1.	Md. Azizar Rahaman, F/N:Lat. Abdul Karim Vill: Mithapukur, Rangpur	BRRI dhan29	15/02/2013	21/02/2013	24
2.	Md. Bellal Miah, F/N:Md. Nemu Fakir Vill: Mithapukur, Rangpur	BRRI dhan29	17/02/2013	22/02/2013	18
3.	Md. Abdul Halim, F/N:Md.Samsul Huqe Vill: Mithapukur, Rangpur	BRRI dhan29	15/02/2013	20/02/2013	22
4.	Md. Samsul Huqe, F/N:Md. Abdur Rahim Vill: Mithapukur, Rangpur	BRRI dhan29	16/02/2013	21/02/2013	16
5.	Md. Shabul Islam, F/N:Md. Oshman Ali Vill: Mithapukur, Rangpur	BRRI dhan29	18/02/2013	22/02/2013	18
6.	Mst. Khaleda Begum, S/N:Md. Tashlim Miah Vill: Mithapukur, Rangpur	BRRI dhan28	15/02/2013	20/02/2013	20

7.	Md. Tashlim Miah, F/N:Md. Tafir Uddin Vill: Mithapukur, Rangpur	BRRI dhan28	15/02/2013	19/02/2013	18
8.	Mst.Kulsum Begum, S/N:Md.Shalom Vill: Mithapukur, Rangpur	BRRI dhan28	16/02/2013	20/02/2013	17
9.	Md.Yasin Ali, F/N:Md. Abul Hossain Vill: Mithapukur, Rangpur	BRRI dhan28	17/02/2013	21/02/2013	22
10.	Md.Eshahak Ali , F/N:Md. Abul Sarkar Vill: Mithapukur, Rangpur	BRRI dhan28	18/02/2013	23/02/2013	21
11.	Mst. Jesmin Begum, S/N:Md. Younus Ali Vill: Mithapukur, Rangpur	BRRI dhan28	19/02/2013	22/02/2013	20
12.	Md. Iddrish Ali, F/N:Md. Abul Sarkar Vill: Mithapukur, Rangpur	BRRI dhan28	17/02/2013	22/02/2013	17
13.	Md. Mozammal Miah, F/N:Md.Bellal Miah Vill: Mithapukur, Rangpur	BRRI dhan28	15/02/2013	21/02/2013	16
14.	Md. Haydar Ali, F/N:Md. Mikir Pramanik Vill: Mithapukur, Rangpur	BRRI dhan28	15/02/2013	20/02/2013	20
15.	Md.Abdul Hannan, F/N:Md.Lachu Miah Vill: Mithapukur, Rangpur	BRRI dhan28	16/02/2013	21/02/2013	21
16.	Mst. Belina Akter, S/N:Md. Abul Miah Vill: Mithapukur, Rangpur	BRRI dhan28	17/02/2013	19/02/2013	18
17.	Md. Tazul Islam, F/N:Md. Bellal Miah Vill: Mithapukur, Rangpur	BRRI dhan28	17/02/2013	21/02/2013	22
18.	Md. Mithu Miah, F/N:Md. Bulu Miah Vill: Mithapukur, Rangpur	BRRI dhan28	15/02/2013	20/02/2013	20
19.	Md. Nazmul Huda, F/N:Md.Nashim Uddin Vill: Mithapukur, Rangpur	BRRI dhan28	15/02/2013	19/02/2013	17
20.	Md. Sabur Ali, F/N:Md. Nazmul Huda Vill: Mithapukur, Rangpur	BRRI dhan29	13/02/2013	17/02/2013	20
21.	Md. Tahidul Islam, F/N:Md.Tafazzol Hossen Vill: Mithapukur, Rangpur	HYBREED dhan	14/02/2013	18/02/2013	18
22.	Md. Akterul Islam, F/N:Md.Abdul Bari Vill: Mithapukur, Rangpur	HYBREED dhan	15/02/2013	18/02/2013	21
23.	Md. Abu Taiher, F/N:Md. Tafazzol Hossen Vill: Mithapukur, Rangpur	HYBREED dhan	15/02/2013	19/02/2013	22
24.	Md.Zeym Miah, F/N:Md. Rustom Ali	BRRI dhan28	15/02/2013	20/02/2013	20

	Vill: Mithapukur, Rangpur				
25.	Md. Shadat Hossen, F/N:Md. Afsar Ali Vill: Mithapukur, Rangpur	BRRI dhan29	17/02/2013	21/02/2013	18
26.	Daiul Kumar, F/N: Kamol Chandro Vill: Mithapukur, Rangpur	BRRI dhan28	18/02/2013	22/02/2013	20
27.	Md. Rafikul Islam, F/N:Md. Abdur Rashid Vill: Mithapukur, Rangpur	BRRI dhan28	15/02/2013	20/02/2013	20
28.	Md.Rabiul Islam, F/N:Md. Abdur Rashid Vill: Mithapukur, Rangpur	BRRI dhan28	15/02/2013	20/02/2013	18
29.	Md. Abdur Rashid Miah, F/N:Md.Lachu Miah Vill: Mithapukur, Rangpur	BRRI dhan28	14/02/2013	18/02/2013	17
30.	Md. Shohidul Miah, F/N:Md. Bacchu Miah Vill: Mithapukur, Rangpur	BRRI dhan28	15/02/2013	20/02/2013	20
31.	Md. Tota Miah, F/N:Mohammad Vill: Mithapukur, Rangpur	BRRI dhan28	15/02/2013	19/02/2013	18
32.	Md. Abdur Rahaman, F/N:Md. Abbas Miah Vill: Mithapukur, Rangpur	BRRI dhan28	14/02/2013	18/02/2013	19
33.	Md. Serajul Islam, F/N:Md.Sharab Hossain Vill: Mithapukur, Rangpur	BRRI dhan28	15/02/2013	20/02/2013	20
34.	Md. Monjurul Islam, F/N:Md.Abdus Salam Vill: Mithapukur, Rangpur	BRRI dhan28	15/02/2013	20/02/2013	18
35.	Md. Rezaul Islam, F/N:Md. Sharab Hossain Vill: Mithapukur, Rangpur	BRRI dhan28	15/02/2013	20/02/2013	20
36.	Md. Ashikul Islam, F/N:Md. Hazrat Ali Vill: Mithapukur, Rangpur	BRRI dhan28	15/02/2013	19/02/2013	20
37.	Dhirendro Nath, F/N:Lat.Thakur Dash Vill: Mithapukur, Rangpur	BRRI dhan29	14/02/2013	18/02/2013	24
38.	Tapon Chandro Sarkar, F/N:Md.Bijoy Chandro Vill: Mithapukur, Rangpur	BRRI dhan28	15/02/2013	21/02/2013	22
39.	Ripik Chandro Sarkar, F/N:Guru Charon Kabiraj Vill: Mithapukur, Rangpur	BRRI dhan28	18/02/2013	22/02/2013	20
40.	Md.Abdur Raouf Miah, F/N:Md. Sadek Hossain Vill: Mithapukur, Rangpur	HYBREED dhan	14/02/2013	20/02/2013	24
41.	Md. Tuta Miah , F/N:Md.sadek Hossain Vill: Mithapukur, Rangpur	HYBREED dhan	15/02/2013	20/02/2013	19
42.	Md. Bashed Miah, F/N:Md.	HYBREED	16/02/2013	21/02/2013	18

	sadek Hossain Vill: Mithapukur, Rangpur	dhan			
43.	Md. Montu Miah, F/N:Md. Mojahar Ali Vill: Mithapukur, Rangpur	BRRI dhan29	13/02/2013	20/02/2013	17
44.	Md. Piaush Ali, F/N:Md.Abdur Raouf Miah Vill: Mithapukur, Rangpur	BRRI dhan29	15/02/2013	20/02/2013	22
45.	Md. Sahajhan Miah, F/N:Md. Bacchu Miah Vill: Mithapukur, Rangpur	BRRI dhan28	15/02/2013	20/02/2013	18
46.	Md. Khalil Miah, F/N:Md. Bacchu Miah Vill: Mithapukur, Rangpur	BRRI dhan28	15/02/2013	19/02/2013	20
47.	Md. Amirul Islam, F/N:Md. Raza Miah Vill: Mithapukur, Rangpur	BRRI dhan28	17/02/2013	20/02/2013	20
48.	Md. Raza Miah, F/N:Md. Hydar Ali Vill: Mithapukur, Rangpur	BRRI dhan28	18/02/2013	22/02/2013	18
49.	Md. Anarul Islam, F/N:Md. Badsha Miah Vill: Mithapukur, Rangpur	BRRI dhan28	17/02/2013	20/02/2013	16
50.	Md. Abu Talib, F/N:Md. Hydar Ali Vill: Mithapukur, Rangpur	BRRI dhan28	15/02/2013	18/02/2013	15
51.	Md.Abu Kalam, F/N:Md. Hydar Ali Vill: Mithapukur, Rangpur	BRRI dhan28	17/02/2013	20/02/2013	18
52.	Md.Siddeek Miah, F/N:Md. Hydar Ali Vill: Mithapukur, Rangpur	BRRI dhan28	20/02/2013	23/02/2013	18

Appendix- P

Large scale validation trials of rice transplanter during Boro, 2013

Table P1: Large scale validation trials of Rice Transplanter during Boro/2013

Sl no.	Name of Farmers	Name of fathers	Name of place	Area, decimal
1.	Md. Habibul Uddin	Moyen Uddin Bishawash	Hijlakor	150
2.	Md. Mojibar Shakh	Abdul Shakh	Hijlakor	24
3.	Md.Yakub Ali	Azahar Ali	Hijlakor	33
4.	Md.Arzan Ali	Pacha Shakh	Hijlakor	33
5.	Md.Eajuddin	Ujal Shakh	Hijlakor	66
6.	Md.Kiyamoddin shakh	Ujal Shakh	Hijlakor	66
7.	Md.Neyamot Shakh	Kiyamoddin shakh	Hijlakor	20
8.	Md. Barkot Ali	Ahammod Ali	Hijlakor	36
9.	Md.Abdul Lothif	Ahammod Ali	Hijlakor	36
10.	Md.Abdur Rashid	Ahammod Ali	Hijlakor	36
11.	Md.Azmot Ali	Ahammod Ali	Hijlakor	50
12.	Md.Habibor Bisawash	Mozahar Ali	Hijlakor	41
13.	Md.Alomgir Hossen	Hashen Ali	Hijlakor	20
14.	Md.Altaf Ali	Hashen Ali	Hijlakor	20
15.	Md.AnsarAli	Hashen Ali	Hijlakor	33
16.	Md.Abdul Zabbar	Montu Shakh	Hijlakor	20
17.	Md.Safiuddin	Mona shakh	Hijlakor	33
18.	Md. Samsuddin Shakh	Abdul Shakh	Hijlakor	66
19.	Sree.Nepal Chandro	Mohini Chandro	Hijlakor	99
20.	Md.Ansar Ali	Abdul Karim	Moragacha	50
21.	Md.Akbar Ali	Abdul Aziz	Hijlakor	33
22.	Md.Sadek Ali	Abdur Rahaman	Hijlakor	50
23.	Md.Rejon Ali	Abdur Rahaman	Hijlakor	100
24.	Md.Khejon Ali	Abdur Rahaman	Hijlakor	100
25.	Sree. Susanto Kumar	Nironjon Kumar	Moragacha	40
26.	Md.Akmol Hossain	Amzad Hossen	Hashimpur	33
27.	Md.Mozibar Rahaman	Asgar Malitha	Hashimpur	25
28.	Md.Fazo Malitha	Asgar Malitha	Hashimpur	17
29.	Md. Bellal Hossen	Fazol Shakh	Hijlakor	17
30.	Md.Faljer Ali	Arman Ali	Hijlakor	17
31.	Md. Hasen Mollah	Afsar Mollah	Hijlakor	33
32.	Apu Thakur	Kanu Thakur	Moragacha	100
33.	Md.Alim	Delbar Mollah	Hijlakor	133
34.	Md.Anir Uddin	Chad Ali	Hijlakor	17
35.	Md.Mela Malitha	Hukum Malitha	Hijlakor	17
Total				**1664**